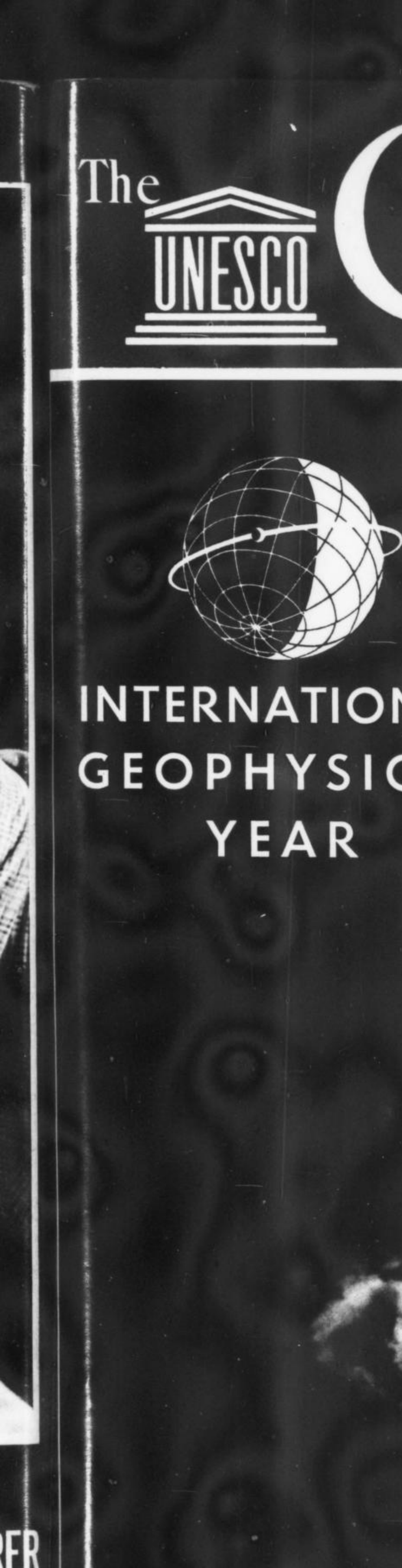
A WINDOW OPEN ON THE WORLD

The UNESCO Courier

INTERNATIONAL GEOPHYSICAL YEAR



History's greatest science research project

OPERATION GLOBE

Each of the 2,500,000,000 persons on earth lives in a local culture that is distinctive in its dress and social customs, in its habits of living and thinking, in its government and politics. Until recently most cultures regarded all others as strange or even inferior. A visitor from a far planet would be fascinated by this remarkable diversity. Yet he would be equally impressed by what men have in common, the essential humanity that is often not visible to us across the geographical and cultural barriers.

The diversity of human cultures is paralleled by a striking diversity in the environment, in the climate, the terrain and the soil. Mountains and plains, deserts and humid forests, icy winters and the blazing sun, rivers and the many arms of the sea are contrasting scenes that offer different foods and clothing, from rice to blubber, from grass skirts to polar parkas. Plants and animals vary with the environment, and man adapts to them all.

But the vast variety of scenery has an underlying unity too. It all derives from the same materials and forces that compose our world—the same rocks and waters, the power of the sun, the rotation and revolution of the earth itself, the tilt of its axis, the weight of the continents, the heat of the deep plastic interior, the rushing rivers, great ocean currents and the winds that brush the sky. Acting through the ages, they have shaped our geography as the latter has shaped our lives. For both Man and Nature, the essential unity is hidden in the many forms.

It is the function of science to observe the myriad things and events that comprise the universe and to discover the relations between them, to explain their causes, as we say. Thus science has evolved new concepts and basic laws which again simplify and unify the diversity of nature. All the numberless materials of the earth are composed of a small number of chemical elements whose atoms are in turn simple combinations of protons and electrons. Gravitation accounts for the motions of the planets and the fall of an apple. The principle of evolution explains the development of all the species of plants and animals from simple primitive forms. Relativity is a unified concept on a cosmic and superhuman scale.

All this leads to understanding. The unknown becomes known and the complex becomes simple. From this point of view it is obvious that we all live on one world, one celestial globe that is our common heritage. Each man may see only his own acre but the combined view of the human race, in the form of organized science, sees it whole. The individual sciences of astronomy, geology and geophysics, geography and oceanography, climatology and meteorology, to list only a few, have made this world comprehensible, have enabled us to foresee the course of natural events such as the seasons and the weather.

However, compared with the mystery of nature we know but little now. We live at the bottom of a great ocean of air and cannot truly see the sun and the stars because so much of their light is absorbed by the atmosphere and never comes down to us. Cosmic rays and millions of swift meteors are altered or destroyed high in the sky where we have no observatories. Weather can be predicted a few days in advance, though none too well, but the complexities of the atmosphere prevent accurate forecasting for weeks or months ahead. Currents on the surface of the ocean, like the Gulf Stream and the Japan Current, determine much of the earth's climate; but there are deep currents too that are equally important, though they are as yet unmapped. A whole vast continent, probably full of precious resources, lies about the southern pole, almost unexplored. Electronic and magnetic storms rage above and around the earth, visible as the aurora borealis and the aurora australis, but a challenging mystery in their effects on human communications by radio and even by wire. Science cannot be content with our present ignorance of our planet. All our past experience shows that more knowledge will solve these many mysteries too, will bring understanding and then add still more resources for man's use.

What remains to be explored is global, not local. None of the problems that have been mentioned can be investigated in the laboratories or from observatories of a single country. The winds on high, the rivers in the sea, the forces of gravity and magnetism, the radiations that bombard the earth from outer space, know nothing of national frontiers. If they are to be understood it must be by the joint action of many nations. Co-operation among scientists across national borders is not uncommon, but what is required now is a large number of observations of the same phenomena made at the same moment at many points on the earth. It amounts to this: that humanity as a whole must now study the planet as a whole.

For the first time in history this is now possible. The nations of the earth are joined together in the United Nations. Their studies of the weather and climate are centered in the World Meteorological Organization. The advancement of science as such, and international co-operation in science especially, are one of the functions of UNESCO. Whatever political differences still separate the nations, the ten years of UNESCO have created a cordial unity among all the nations in the pursuance of science, education and culture. So the time is now ripe for such a world-wide study.

Thus a new age is opened by the International Geophysical Year, to which this issue of THE UNESCO COURIER is devoted. How it will change our concepts of the universe and our understanding of the forces that play upon and within the earth will not be known for several years. What benefit will accrue to mankind from the new knowledge will develop in future decades. But the new age begins with the concerted action of many peoples and by the carefully organized researches of many thousands of scientists the world over. For the first time the peoples of the earth have joined to study their common and fundamental scientific problems together.

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10th YEAR
SEPTEMBER 1957
No 9

Special Issue:
THE INTERNATIONAL GEOPHYSICAL YEAR

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COVER PHOTO

Most ambitious project of the International Geophysical Year will be the launching of an artificial satellite carried by a giant, three-stage rocket to a height of 300 miles and hurled into space at 18,000 m.p.h. Here, Viking rocket (first-stage) is fired with third-stage rocket to test high altitude separation methods. The rocket reached a peak velocity of 3,500 m.p.h. USIS

MAN OF 'THE YEAR' —THE SCIENTIST

EVEN its name needs explanation. It is more than a year: eighteen months, from July, 1957, through December, 1958. It is more than geophysical. The prefix *geo* comes from the ancient Greek word for the earth, and identifies the earth sciences of geology, geography, geodesy and geophysics. But the Year's programme also involves astronomy, meteorology, oceanography, glaciology and other sciences that contribute physical studies of the earth and of its environment in space. It is also rather more than international, for the 66 nations that are participating in it include almost all countries that are capable of such scientific effort. It is a world venture.

The Year is certainly more than a period of time. An immense amount of research will be done high in the sky, deep in the sea and on all the continents by more than 5,000 scientists at an estimated cost of some $500,000,000. The Year is in fact an organized global campaign to observe and measure features of the earth and its vicinity that have heretofore been beyond man's reach.

The investigations fall into three major groups.

Most remote from the thin skin of the planet where men spend their lives are the studies of the upper atmosphere. There are electrons and radiations from the sun, the "shooting stars" that burn and fall to earth each day. There the sun's rays are filtered and electrically charged atoms form a mirror for the reflection of radio waves. Least understood are the cosmic rays from outer space. Here is the outermost frontier of our planet that must be mastered before man can sail through it and embark on spaceflight.

The second field of investigation is that ever-changing mixture of air and water in which we are immersed, the lower atmosphere. Its daily variations are the weather, determined by the sun's rays, by the evaporation of water from the oceans, thus by the temperature of the ocean waters and of glaciers and ice-fields. Differences in pressure force the flow of air from high to low. Hence the winds and the storms, impeded by mountains, lifted on high when there is no place else to blow, and cooled and stripped of moisture as rain or snow.

But the underlying causes of climate and weather changes are complex. They depend on changes in the sun's radiation, on the available water, and on unpredictable high winds in the upper atmosphere. Weather is notoriously local but its causes are global. It will remain a favourite but fruitless subject of conversation in every village until researches on the sun, the upper atmosphere, the ocean currents, the ice-fields of the Arctic and Antarctic, and simultaneous observations of air conditions at different heights and at thousands of points on earth and on the sea have been made during the Year. Better understanding of the atmosphere will at last permit reliable forecasting of the weather for weeks and perhaps months ahead and of climatic changes for centuries into the future.

The third major interest during the Year is the solid earth itself. Today only one area remains unexplored: the great Antarctic continent, nearly twice as large as Europe. It will be explored not so much to map its possible wealth nor for prospective human habitation but because its colossal ice masses have a profound influence on the world's weather.

But far more vital will be studies of the earth's interior as a basis for earthquake and volcanic predictions, for an understanding of the earth's magnetism and the strange variations in the force of gravity at different points. Such studies involve seismology and geology and the fundamentals of geophysics as a whole.

The largest benefit, however, will accrue not from any of these investigations in themselves but from the correlation between results from different sciences and apparently unrelated researches. There has never before been such a concerted and concentrated attack on the frontier of our ignorance. It will seem a different world when the Year is over.

THE WHY AND HOW OF I.G.Y.

© Life Magazine 1957

INTERNATIONAL HEADQUARTERS for the I.G.Y. is situated at Uccle, Belgium. Here, Special I.G.Y. Committee of eminent scientists meets frequently, sends out its suggestions and progress reports. Members of Special Committee shown here are, from left Vladimir Beloussov of U.S.S.R., Lloyd V. Berkner of the U.S. (Vice-president of committee); Marcel Nicolet of Belgium (Secretary General); Jean Coulomb of France, Sidney Chapman of Great Britain (President).

TWICE before this Year there were limited programmes of international co-operation to study geophysical phenomena. Both were known as Polar Years because their primary purpose was the understanding of Arctic weather. The first was 75 years ago, from August 1882 to August 1883; the second fifty years later, during the same months of 1932 and 1933.

Twelve nations maintained fourteen observation posts in the Arctic area during the First Polar Year and 34 farther south at which hourly records of the meteorological and magnetic conditions were made and the Northern Lights, the aurora borealis, were systematically observed.

The Second Polar Year included observations in the Antarctic, and its scope was extended to include the study of ionization in the upper atmosphere and its effects on radio communication over most of the earth. Both poles had then been reached by explorers and the scientific equipment available was far superior to that of fifty years earlier.

In the years since then both the need for geophysical knowledge and the means for acquiring it have grown mightily. Planes, radar, radio-telescopes, sound-wave reflection and remote-control electronic systems, to say nothing of high-altitude rockets, are among the new tools for research that have been perfected during the course of the past two decades.

This led Dr. Lloyd V. Berkner, president of the Associated (American) Universities, Inc. and a former president of the American Geophysical Union, to propose in April, 1950, that the interval between Years be cut from 50 years to 25 and that the Third Polar Year be planned for 1957-58.

In October 1951, the proposal was referred to the International Council of Scientific Unions, the logical organization to launch the entire project since it is the central body that comprises nearly all the individual international scientific unions, thus represents all the sciences as well as the interested nations.

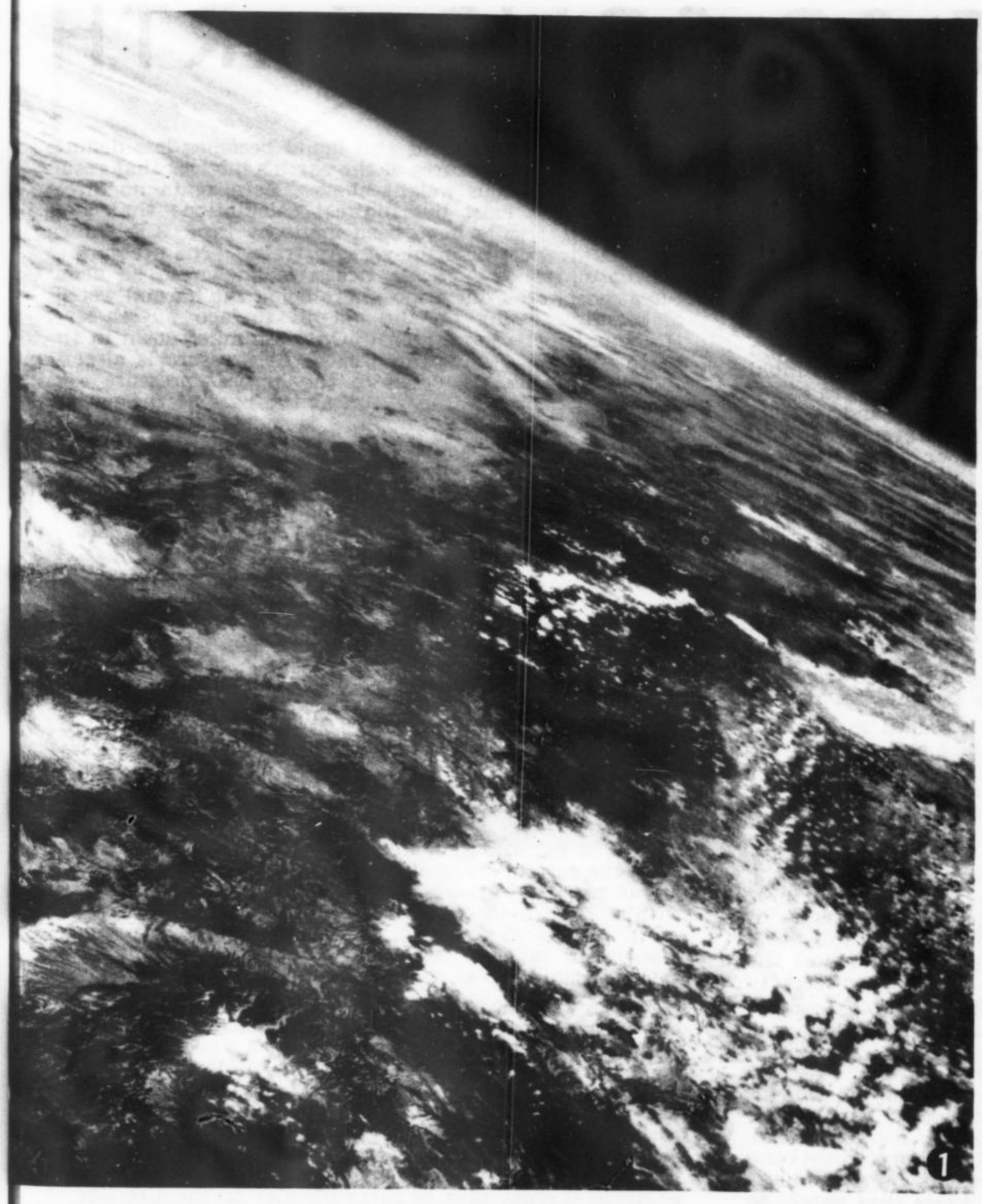
In 1952 the International Council broadened the scope of the project by giving it its present name and established the Special Committee for the International Geophysical Year. When the Committee was assured of financial support for its initial operations by UNESCO it proceeded to organize the ambitious project and established a permanent Bureau to act as executive headquarters. It is located in Belgium at Uccle, a suburb of Brussels, and is headed by Prof. Sydney Chapman of Queen's College, Oxford, as President, Dr. Lloyd V. Berkner of the United States as Vice-President, and Prof. Marcel Nicolet of Belgium as General Secretary. They were later joined by Prof. V. V. Beloussov of the U.S.S.R. and Prof. J. Coulomb of France. Vice-Admiral Sir Archibald Day has been appointed as Co-ordinator of I.G.Y. Operations.

However, most of the costs of the actual researches are borne by the co-operating governments and in part by the various national and international scientific societies and by individual universities and research institutions. The amounts of the national expenditures are not generally available but an instance is the planned expenditure of $80,000 to $90,000 by Iran on geophysical data in the Near East. The U.S. Congress has appropriated $39,000,000 to the National Academy of Sciences for the expenses of the U.S. programme. This is apart from the additional expenses involved in the exploration of the Antarctic Continent and in the launching of an artificial earth-satellite for high-altitude observations.

The magnitude of the programme in each country depends on its own financial support, and is supervised by a national committee. The chairmen of these committees are organized as an Advisory Council for the planning of the world programme. An official Reporter has also been appointed, one for each of the thirteen major fields of study, to co-ordinate the work within each specialty but on a world basis. Finally, an Advisory Committee on Publications will supervise the preparation of the "Annals of the Geophysical Year" which will be published by the Pergamon Press after the close of the Year. Sir Harold Spencer-Jones, Britain's former Astronomer Royal, is to be Editor-in-Chief.

GERALD WENDT

Articles in this issue on the International Geophysical Year were written by Dr. Gerald Wendt, science consultant to the Editor of *The Unesco Courier* and Special Editor of the present issue. Formerly a professor of chemistry at the University of Chicago and Dean at the Pennsylvania State College, Dr. Wendt has devoted recent years to the interpretation of science and its social consequences in public lectures, on the radio and by television. He has been Director of Education at the World's Fair in New York, Science Editor of the American weekly, *Time*, and Editorial Director of the monthly, *Science Illustrated*. For three years (January 1952 to December 1954) he was Head of the Division of Teaching and Dissemination in Unesco's Department of Natural Sciences. His articles on science in *The Unesco Courier* and *Unesco Features* have been translated into many languages and reprinted all over the world, in particular those he wrote for the special issue of *The Unesco Courier*, "The Promise of Atomic Power", dated December 1954. He is now president of the Unesco Publications Center in New York.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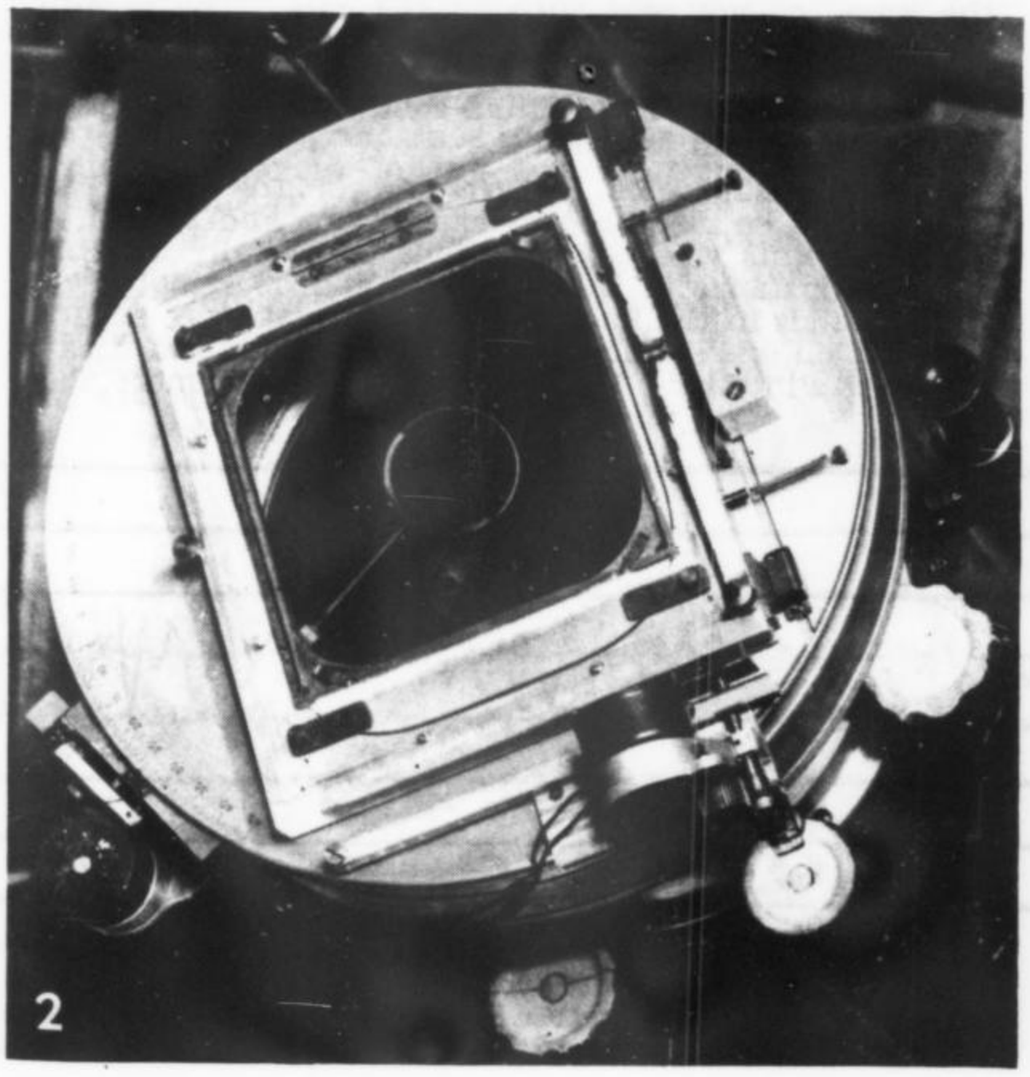
MEASURING THE EARTH FROM THE MOON AND STARS

During the International Geophysical Year teams of specialists will be exploring the earth on every level, from the upper atmosphere to the ground—and below its surface. Art of photographing the earth from rockets has now been developed to a high degree. Photo (l) was taken from a height of 101 miles. It reveals about 300,000 square miles of New Mexico, Arizona, California and the Mexican province of Sonora. To clear up doubts about the exact size and shape of the earth, scientists will be using a remarkable instrument, the Markowitz Moon Camera (2) which takes photographs of the moon against a background of fixed stars (3). These cameras will be operating from twenty stations during I.G.Y. Results will enable points on earth's surface to be fixed with a higher precision than ever before. From Moon Camera photographs, distances between continents, now known to within 100 to 130 metres, can be calculated with an average error of only 30 to 35 metres. Still more accurate measurements are expected from observations of the artificial satellites. (See page 32)

USIS photos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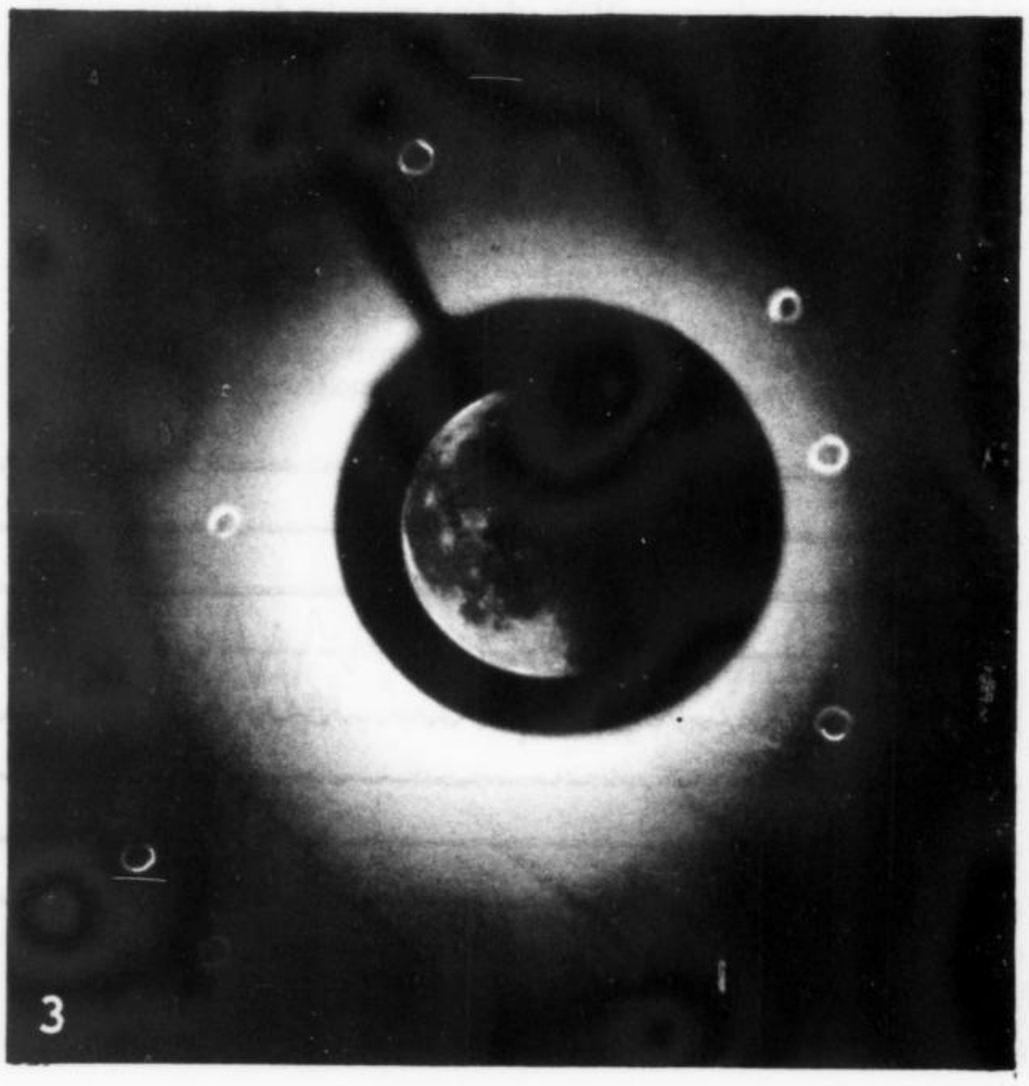
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THE NOT SO SOLID EARTH

In the scientific attack on so complex a problem as the complete understanding of the earth, the first step must be to separate it into smaller problems and to approach them one by one. The Year does this first of all by eliminating all human and biological questions, important as they are. This is a Geophysical Year and only the physical sciences are involved. But even from that restricted point of view, the earth has three major aspects.

First, it is a celestial object, a planet rushing through space at a velocity of 18.50 miles per second in its annual orbit around the sun that is some 93 million miles away. It constantly encounters radiations, particles and meteors which add thousands of tons to its mass every year and have a profound effect upon the upper atmosphere as they impinge upon it.

Second, it is an almost spherical mass of 6,600 million million million tons (in figures: 6.6 followed by 20 zeros), that as a whole is 5.5 times as dense as water. The globe has a diameter of 7,920 miles. It is composed of three major layers: a central core, 4,300 miles in diameter, that may be metallic and probably is fluid, surrounded by a magma, 1,800 miles thick of compressed rigid rock, and around this the thin crust, only about 20 miles thick, that is made up largely of rocks that have descended from the surface after chemical action by the sea and by air.

And the third aspect of the earth is known in common speech as the surface, between the globe and the sky, the abode of life and the scene of history. It extends over 197 million square miles. Strictly speaking, it is not a simple surface but a complex of three separate interfaces, one where earth meets water on the sea bottom, another between the sea and the air, and a third where the dry land is itself exposed to the atmosphere. This is the smallest of the three and covers only about one fourth of the entire area. Here most of the geophysical studies of the Year are concentrated in terms of geography and geodesy, Antarctic exploration, weather studies and the exploration of the great heights. They are closest to man's common life and natural interest.

Sixty million lbs. per sq.in.

But logically it is the solid earth that is the base of geophysical science. It is also the least explored. The deepest mine goes down about 10,000 feet, less than a tenth the thickness of the crust. Oil wells, however, have penetrated to more than twice that depth, to 22,000 feet, nearly one-fifth of the way to the underlying magma. The materials thus penetrated are the familiar surface rocks. Such borings, however, do give direct evidence of heat in the interior. In deep mines the temperature rises about 54°F per mile of depth. If this rate continued, the temperature at the centre of the earth would be above 200,000°F. But it is practically certain that the rate of increase is much less farther down so that the temperature of the centre is estimated to be between 3,600 and 11,500°F. Exact knowledge is lacking.

Under surface conditions such temperatures would be adequate to melt or liquefy most materials. But the distinction between solid and liquid becomes less definite under the high pressures of the earth's interior that result from the enormous weight above. Here again no direct measurements exist but indirect calculations that gave astonishing results have been made by Prof. K.E. Bullen of the University of Sydney in Australia. The pressure at the bottom of the Pacific Ocean is known to be about 800 atmospheres, one atmosphere being the normal weight of the air pressing on the earth's surface at sea-level (15 pounds per square inch). Only 200 miles down in the earth's mantle—below the crust—the pressure is already 100,000 atmospheres, equal to the highest pressure ever produced in a laboratory. But at the base of the mantle 1,800 miles down, the pressure is more than a million atmospheres and at the centre of the earth nearly four million. It is difficult to imagine the condition of any form of matter at a temperature of perhaps 10,000°F and under a pressure of 60 million pounds per square inch.

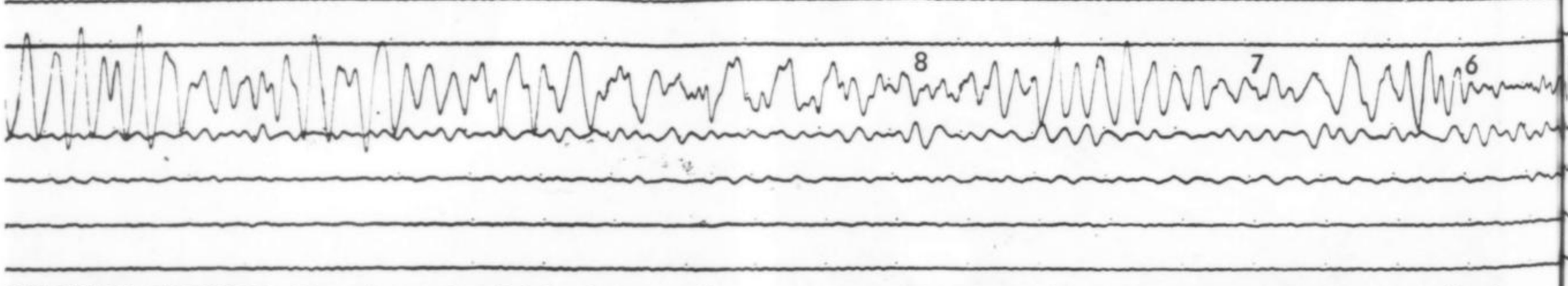
Antarctic 'ice-quakes'

Certainly the density is much higher than at the surface. Professor Bullen has estimated that the rocks just below the crust have a density of 3.3 grammes per cubic centimetre, compared with water at one gramme per cubic centimetre (or 62.3 pounds per cubic foot). But the density increases to 5.5 at the bottom of mantle, then jumps suddenly to 9.5 at the top of the core and increases gradually to 11.5 within the core. This is close to the density of metallic lead at the surface (about 700 lbs. per cubic ft.).

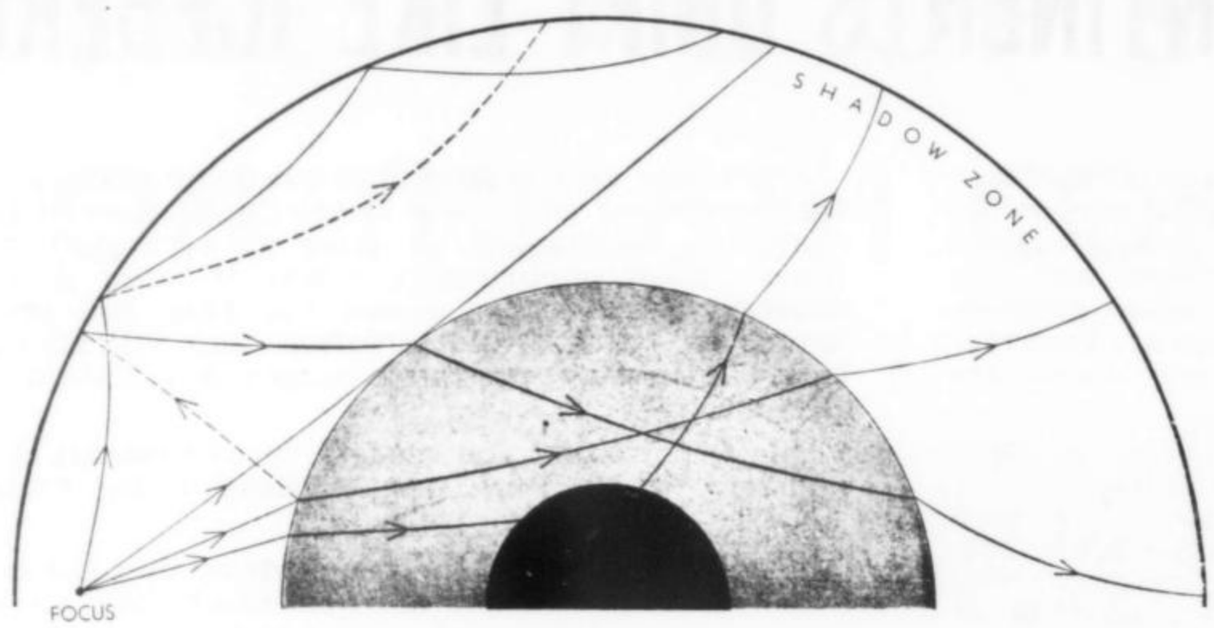
Most of our knowledge of the earth's interior has come from the careful study of earthquakes and the many lesser vibrations that reach the surface from disturbances within. Nearly all are based on the continuous records of earth vibrations made at many points on earth by an instrument called a seismograph, from the ancient Greek word, *seismos,* for an earthquake.

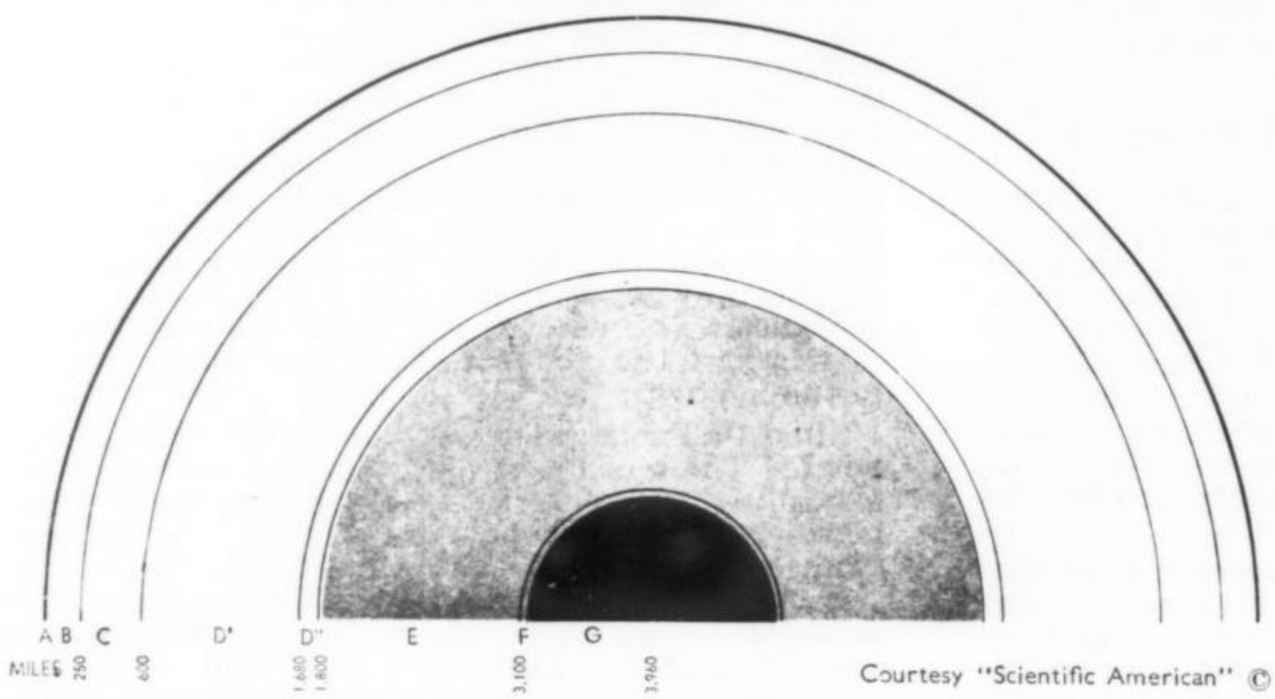
It is by the analysis of seismograph records from different stations that the location of the 'quake itself is determined. The rate of travel of the shock wave through the earth's interior also gives important information on the composition of the magma and the core. For instance pressure waves, in which the motion at each point is in the same direction as that of the wave, pass through the central core, though they are deflected somewhat. But secondary waves, in which the motion of the individual particles is cross-wise, or perpendicular, to the direction of the wave, do not pass through the core. The resulting "shadow" of these waves on the opposite crust is both major evidence for the existence of the core and an indication that it is fluid rather than solid and may be composed of molten iron and nickel.

In the seismological programme of the Year earth tremors will be measured by expeditions and special stations at points where observations are usually unobtainable, for instance in the Antarctic and on remote equatorial islands in the Pacific. This is to get more accurate information on seismic events in those areas and thus on the earth's interior. This, in turn, will reveal more about



TELLTALE TREMORS. Most of our knowledge of the earth's interior has come from studies of waves set up by earthquakes and from other vibrations recorded by seismologists. To obtain still more accurate information, earth tremors that occur during the I.G.Y. will be measured in places where observations are usually unobtainable—in the Antarctic and in remote Pacific islands. Typical seismogram (above) is of earthquake on Kamchatka Peninsula in Siberia, whose phases reveal three main types of seismic waves: Primary (P), secondary (S)





Courtesy "Scientific American" © 1955

X-RAYING THE WORLD WITHIN

Waves set up by earthquakes travel through the whole interior of the earth and as they travel from their source their paths are bent and shaped by the shells of the earth's internal structure. By interpreting the story they tell when received on the surface, the seismologist, in effect, "X-rays" the earth. In upper diagram solid lines represent primary shock waves and dotted lines are secondary waves formed by reflection. The only primary waves that can get into "shadow" zone on opposite crust, shown in upper right, are those which enter earth's inner core and are sharply bent. Cross section of earth (lower diagram) is divided into distinct layers through which seismic waves travel at different speeds. Outer core is indicated by lighter tone of shading; inner core by darker tone. Layer marked by A is earth's thin crust.

the nature of magma and the core and of a number of intermediate layers that are now ill-defined.

In another phase of the programme the faint vibrations, called microseisms, will be studied so that seismographs can later be used to detect and locate small disturbances that are not full earthquakes. Finally, in the Antarctic, seismic measurements on man-made explosions—in effect ice-quakes—will be used to measure the thickness of the otherwise impenetrable ice layers.

The Reporter for the seismology programme is Prof. V.V. Beloussov of the Soviet Union.

At first thought gravity would seem to be one of the most constant forces of nature. To be sure, its actual cause is unknown and so is the means by which it acts at a distance—except in the esoteric terms of Einstein's relativity theory. But it is very simply a pull exerted mutually by any two masses of matter upon each other which is proportional to the product of the two masses and inversely proportional to the square of the distance between them. This is simple, accurate and perfectly constant for the pull of the earth as a whole, as it is for any astronomical body.

But on the surface of the earth there are complications and the force of gravity is not uniform. For one thing, the earth is not a true sphere. Because it spins on its axis it is deformed into an "oblate spheroid", hence flattened like many an orange. For this reason a man standing at sea level at one of the poles would be 13 miles nearer the earth's centre than if he stood at the equator. Without changing his mass he would be heavier because at less distance from the centre the force of gravity is somewhat stronger.

There is also a direct complication from the rotation of the earth. Near the equator the rotational velocity is about 1,000 miles per hour. The resulting centrifugal force counteracts the pull of gravity—in effect reduces it.

Furthermore the oblate spheroid is by no means mathematically smooth. If the earth is shaped like a flattened orange, it is like a battered one, with bulges and depressions quite apart from the mountain heights and ocean deeps. The major undulations in the earth's shape again modify the force of gravity at the surface and this time with a sideways pull

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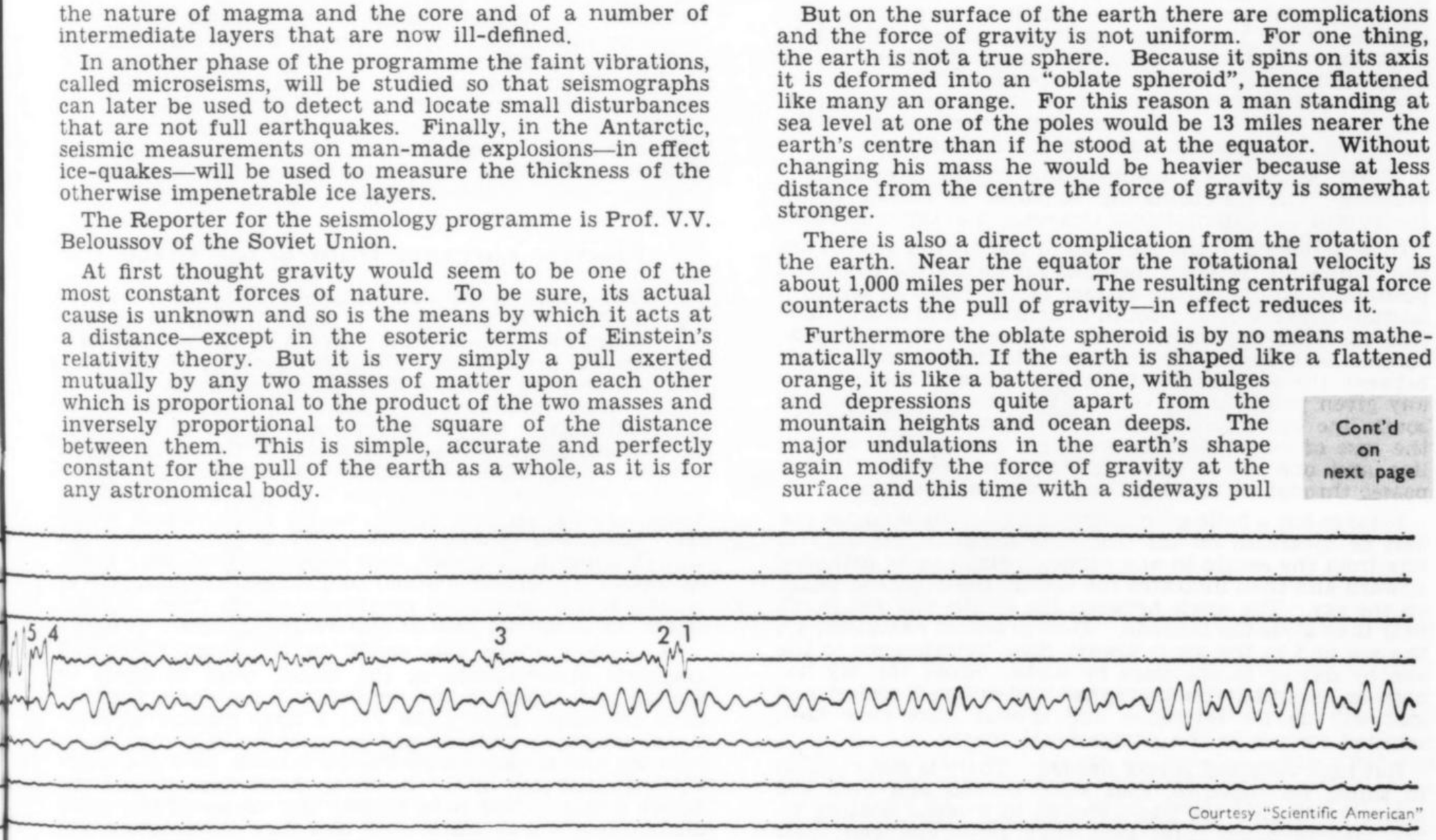


Courtesy "Scientific American"

and surface waves which appear in upper 20 miles or so near earth's surface. The rate of travel of the shock wave through the earth's interior gives vital information on composition of its mantle and core. Secondary waves do not pass through core. Separate lines are actually part of a continuous spiral trace going from right to left on a circular drum. First disturbance recorded is P wave shown by number 1. Then follow the multiply reflected P waves at 2 and 3. S waves begin at point 4 followed by multiply reflected waves at 5,6 and 7. Surface waves start at 8.

NOT SO SOLID EARTH *(Continued)*

DO CONTINENTS DRIFT LIKE ICEBERGS?

so that a plumb line does not point always to the true centre but at an angle. This means that a supposedly vertical line does not point to the zenith among the stars but off to one side. Obviously this interferes with the accurate long-distance surveying that is called geodesy. The result of this, in turn, is that world maps are incorrect because the distances between continents and islands are not accurately known.

There are also changes in the force of gravity at some points which may indicate a slow vertical movement. It is suspected that the Hawaian Islands have thus been lifted several inches. This indicates an "earth-tide" similar to the tides of the ocean but affecting the great rock mantle. They are not yet understood but a schedule of continued measurements of gravity may reveal broad up-and-down movements as if the earth itself were plastic.

Pull of gravity less over oil deposits

FINALLY, there is a practical use for gravity measurements. When large bodies of minerals are present under the surface they can reveal their presence by their effects on gravity when they differ in density from the average rock. Petroleum, for instance, is light and reduces the local pull of gravity. Metallic minerals are often much denser than the usual rock and so increase gravitation. Both oil and mining companies now regularly prospect underground by measuring the gravity at the surface. Many of their data are being turned over to the Year.

The purpose is to make accurate measurements of the force of gravity at as many points on earth as possible. This can be done by measuring the time of swing of a pendulum, but the usual gravimeter is merely a supersensitive spring-scale in which the earth's pull on a small weight is indicated by the stretching of a fine wire of silver or of nickel-steel. There are already hundreds of base stations scattered over the earth that have made many hundreds of thousands of gravitational measurements, including 4,000 points at sea. But it is part of the programme of the Year to extend these stations and to take advantage of special expeditions, such as those to the South Pole. With gravity measurements dotted all over the earth, the earth's actual shape can at last be computed. Then it will be possible to obtain exact figures for the earth's various diameters and for its circumference.

Thirty nations are co-operating in the gravity programme. The Co-ordinating Reporter is Father Lejay, Director of the International Gravimetrical Office in Paris.

Closely related to the purposes of the gravity studies are the completely different methods for measuring the exact position of points on the surface of the earth in terms of latitude (the north-and-south dimension) and of longitude (the east-and-west dimension). These are actually measurements of angles. In the case of latitude it is the angle between the vertical line from the centre of the earth to any given point on the surface and the true north-and-south line which is the axis of rotation of the earth. In the case of longitude it is the angle between the vertical line and one drawn through the zero meridian, which passes through Greenwich Observatory in England.

It takes but a little geometry to see that these angles can best be measured on the sky. For instance, the vertical line from the centre to any surface point can be extended upward and then indicates the zenith, the overhead point, on the sky. The angle between the zenith and the North Star then gives the latitude. Thus practical navigation on the sea and in the air is always done by reference to the sun by day or to the stars by night. Since the sky has been so accurately photographed and mapped, almost any star will do for reference and special stars have been selected for use in the navigational charts.

But high accuracy is now needed. There is some reason to think, for instance, that some islands and even the major continents are like icebergs, in a sense floating on the magma below, and that they have changed their positions radically in the course of geologic time. If they are sliding about then accurate determination of their latitude and longitude would reveal some slight motion within a few years.

A new and very precise photographic technique has now been developed which will locate the position of the moon against a background of stars at accurately measured times. Such photographs, taken at more than twenty different observatories during the Year, will improve all figures on latitude and longitude and will also give the basis for noting possible changes of location as time goes on.

The Reporter for the geodetic measurements of latitude and longitude is Prof. Danjon, Head of the Paris Observatory.

It was easy to think, in former days, that the earth as a whole is a permanent magnet, much like an iron bar magnet, with its magnetic poles at the poles of the earth. This would require that the magnetized atoms inside the earth be permanently arranged side by side with the poles pointing north and south. But at the temperature now known to prevail below the surface, any such permanent arrangement is impossible. Besides, the magnetic pole is not at the geographic North Pole but several hundred miles distant on the Arctic coast of Canada. In addition, the magnetic pole has wandered over the earth far from the North Pole, even into the South Pacific, in previous geological eras. And finally, there are very few places on earth where the compass points true north, or even points to the magnetic pole.

Almost all compass readings need correction to give true north. The amount of deviation has been measured over almost the entire earth's surface and, for the benefit of mariners, with especial care over all the oceans. The study of the world magnetic map indicates that there are two independent components of the magnetic field, with separate causes. The major one is somehow connected directly with the earth's rotation and, if acting alone, would point all compasses to the North Pole.

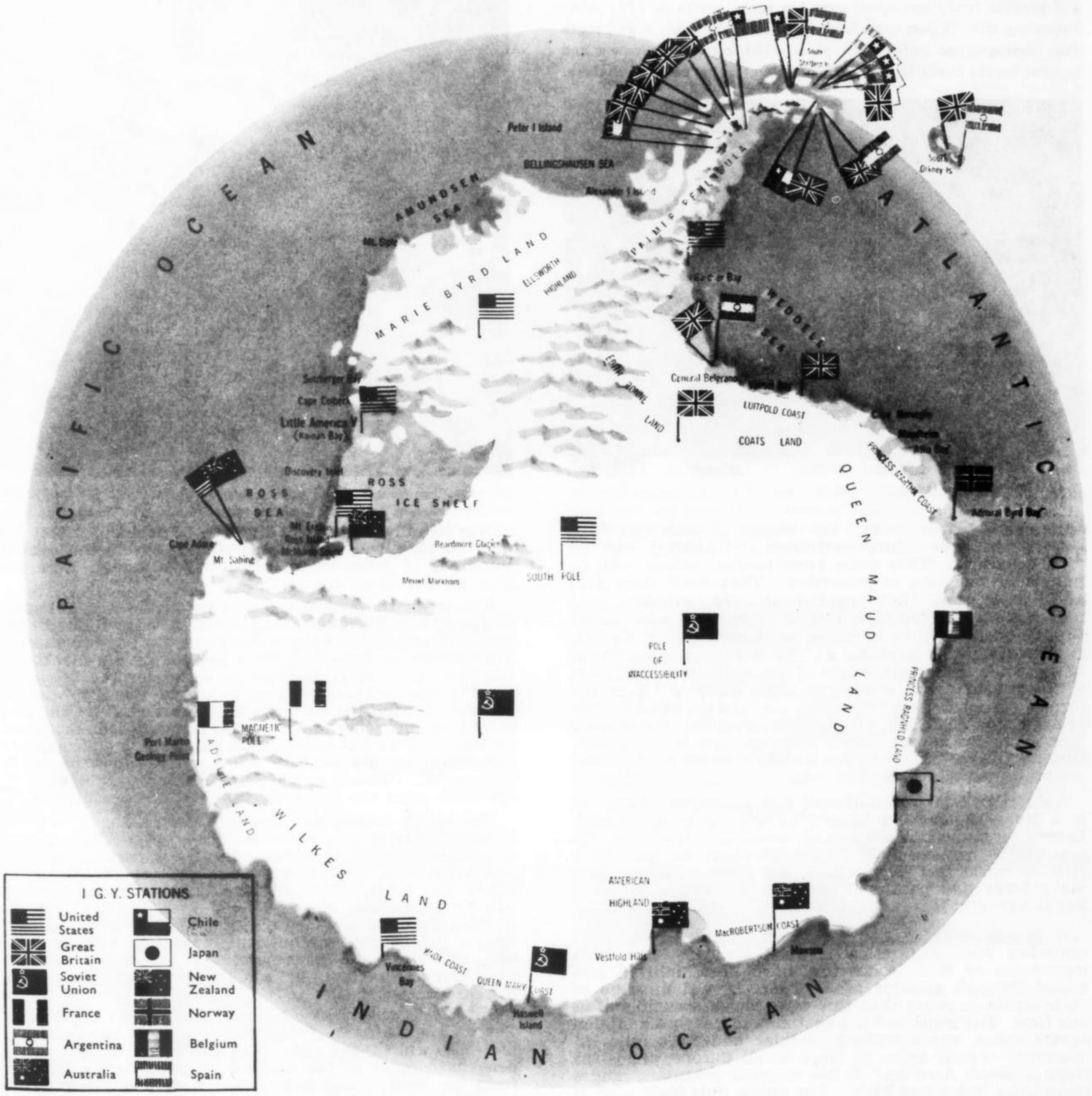
But there are also secondary sources of magnetism produced by some quite different mechanism, which vary irregularly over the earth and change with time, even in the course of a few years, or sometimes months. This secondary or "residual" magnetic field seems to produce magnetic eddies that are in general wandering westward and, at the present rate, will circle the earth in 1,600 years. Their net effect is to produce the magnetic deviations from true north in the main field and to necessitate ever-new mapping of the earth's whole magnetic field. New accurate figures are an important objective of the Year. The actual cause of both the major and the residual magnetic fields is unknown.

Electric currents from outer space

SUPERIMPOSED on the slow variation of the total magnetic field over the course of years is a much smaller variation—so small that it would not be noticed on a compass. It involves only about two percent of the total. But it is properly called a fluctuation because it varies so swiftly that instruments capable of measurements in hundredths of a second are required to study it. These fluctuations probably do not originate in the earth but on the sun. They increase in number and intensity with the number of visible sunspots. Such spots indicate gigantic electrical and magnetic storms on the sun's surface which eject radiations of some sort. When they strike the earth's upper atmosphere, it is supposed that they cause ionization, i.e. electrification, and winds which result in broad electric currents at great heights and these, in turn, affect the magnetic field at the earth's surface.

At present there are about 80 completely equipped magnetic observatories in the world, most of them in Europe and Japan in the temperate zone where fluctuations are least. During the Year a large number of additional magnetic stations will be established across North America and Alaska, on the Pacific Islands, on the Antarctic Continent and in the Arctic areas of Canada and the Soviet Union. The hope is that the causes of the rapid fluctuations will be discovered and that information will be gathered to solve the underlying mystery of the earth's magnetism. Dr. V. Laursen of the Meteorologisk Institut, Charlottenlund, Denmark, is Reporter for the geomagnetism programme.

THE FLAG OF SCIENCE ON THE 6TH CONTINENT



Based on map published in "Natural History" © 1957

THE 'ICE BOX' OF THE WORLD, as Antarctica has been called, greatly influences climate of all countries. During I.G.Y. twelve nations will investigate this mountainous land mass of 6,000,000 square miles (much larger than all of Canada) most of which is a vast plateau averaging 6,000 feet in height, capped by the world's greatest ice-sheet. Something like 90% of the total ice-cover of the world lies on the southern continent. Studies of the possible shrinkage in the Antarctic ice are of vital interest to mankind for if all this enormous ice-sheet melted it would raise the average sea-level all over the world by nearly 200 feet. For the first time more than 6,000 men will be ranging over a continent still no more familiar to us than the visible side of the moon. Map shows locations of principal I.G.Y. stations with flags of nations manning them. Objectives of all nations are the same: to determine how Antarctic influences world conditions in respect of weather, water balance, glaciers, ocean currents, etc, and to make joint geophysical measurements with respect to world's magnetism, cosmic rays, the aurora and other phenomena of the upper air and of the earth's interior.

SIXTH CONTINENT *(Continued)*

PICTURE FROM THE PAST (below) shows Sir Ernest Shackleton's expedition ship (1908-1909) trapped in South polar pack ice. Threatened by gigantic iceberg pushed by deep ocean currents, ship was saved by timely blizzard which deflected iceberg's course. Human endurance and heroism finally triumphed over the white wastes in 1911 when Amundsen and, 35 days later, Scott, reached South Pole. Right, South Pole photographed today from plane which carried equipment and supplies for the scientific observation station that has been set up there.

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USIS

A unique feature of this age, beginning with this Year, is that one whole continent is inhabited only by scientists. They came from twelve nations with no purpose of conquest or possession. They share their data and discoveries, their equipment and supplies, and perchance their hardships, with the men from other lands. Characteristically, for instance, an American, Dr. Gordon D. Cartwright, is working at the Soviet observatory at Mirny while on the other side of the continent, a Russian, V. Rastorgouiev, has a place at Little America. Even the former tension between Great Britain and the governments of Argentina and Chile, all three claiming the area between South America and the South Pole, has now been resolved. Instead, the three nations are maintaining some two dozen scientific bases side by side.

Antarctica is as international now as science itself. It is a true landmark in history as well as in geography. Indeed its name has become an anomaly. It implies the opposite to Arctica, which does not exist, for the North Pole is 10,000 feet deep under the Arctic Ocean. This magnificent new continent deserves a name of its own. For the present it is in truth, if not in name, Science Land.

It is new only to man. The great rock shield that underlies East Antarctica is very ancient. The high mountains of West Antarctica have been uplifted and folded through geologic ages. There is coal in some of their strata to prove that this was tropical swampland at one time. The continent is a vast area of nearly six million square miles, approximately circular and 3,000 miles in diameter—nearly twice as large as all Europe, almost as large as South America. It has majestic mountain ranges more than 15,000 feet high. The South Pole itself is on a plateau some 10,000 feet above sea level, the extent of which is not known because only a small part of it has ever been seen, even from planes. There is a rugged mountainous peninsula, nearly 1,000 miles long, reaching northward toward the Andes of South America—and perhaps an extension of them.

Antarctica has all the variety of any continent but over it all is the endless monotony of the age-old ice sheet, in places 10,000 feet thick. The ice covers almost every inch and extends out to sea. In the great bay that is called the Ross Sea, the ice shelf is 600 to 1,000 feet thick and extends 400 miles from the shore over an area 500 miles wide. It moves steadily seaward at the rate of about four feet per day. Beyond this Shelf Ice, pack ice covers the sea for hundreds of miles in all directions—although from the Pole all directions are north.

Except for the end of the long peninsula that is known in the British Commonwealth as Graham Land and in the United States as the Palmer Peninsula, the entire continent lies within the Antarctic Circle so that for six months of the year none of it sees the sun and for the other six months the sun circles around, low in the sky, without setting. During the dark winter (June and July) the cold is intense. A record of 83°F below zero has been measured on the Shelf Ice but temperature on the high polar plateau has reached as low as 100°F below zero. Under the steady summer sun (December and January) there are days when the snow near the coast becomes wet from melting.

The short, inadequate summers forbid the growth of flowering plants. Only two are known and they are rare, a species of grass and a pink. But the exposed rock areas are sometimes covered with the browns and greens of lichen and moss. The lichen is on the extreme limit of life for it persists in spite of low temperature, can be thoroughly dried by the cold and yet not die, and it is almost independent of nutrients from the ground. The only animal life that such vegetation supports is also of a low order and includes insects like the wingless mosquito, midges and mites.

But if the icy surface is a desert, marine life is plentiful. The cold sea is rich in plankton. Indeed, the Antarctic has been called the most productive sea in the world, perhaps because of the continuous upswelling of waters from the deep, bringing up plant nutrients. Feeding on the plankton are huge numbers of "red krill", a type of shrimp that, in turn, is the food for many fishes, for seals, and for the large population of whales. Both the stately Emperor Penguin and the smaller, agile Adelie Penguins dive into the sea for their food but have their breeding grounds on the ice. They are distinctive of the Antarctic and fossil discoveries indicate that they may have evolved from land birds that lived there during the long ages, long ago, when the climate was mild.

Much remains to be discovered with respect to Antarctic life, both plant and animal, but it will be incidental to the Year's expeditions. The basic, biological

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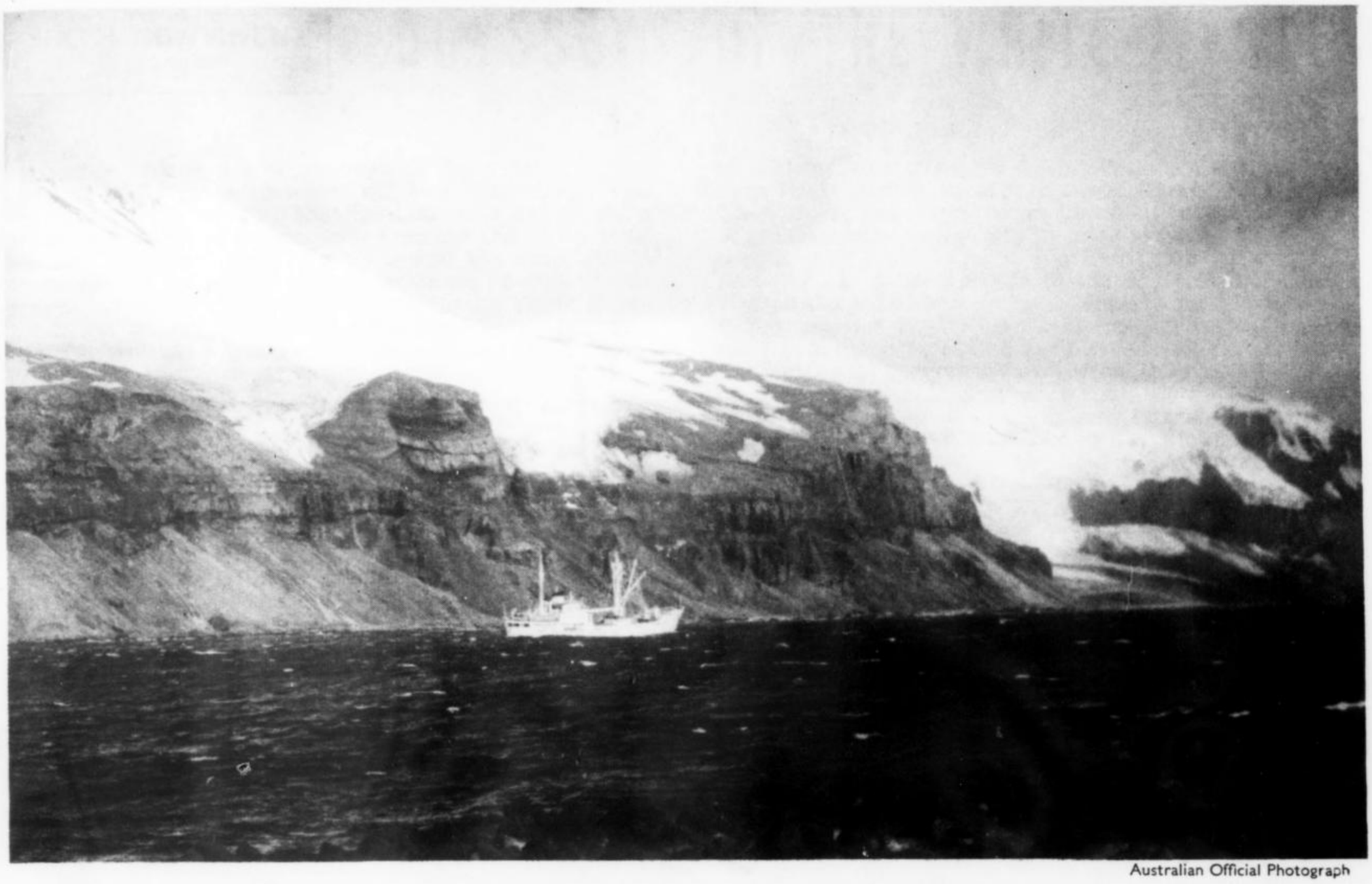


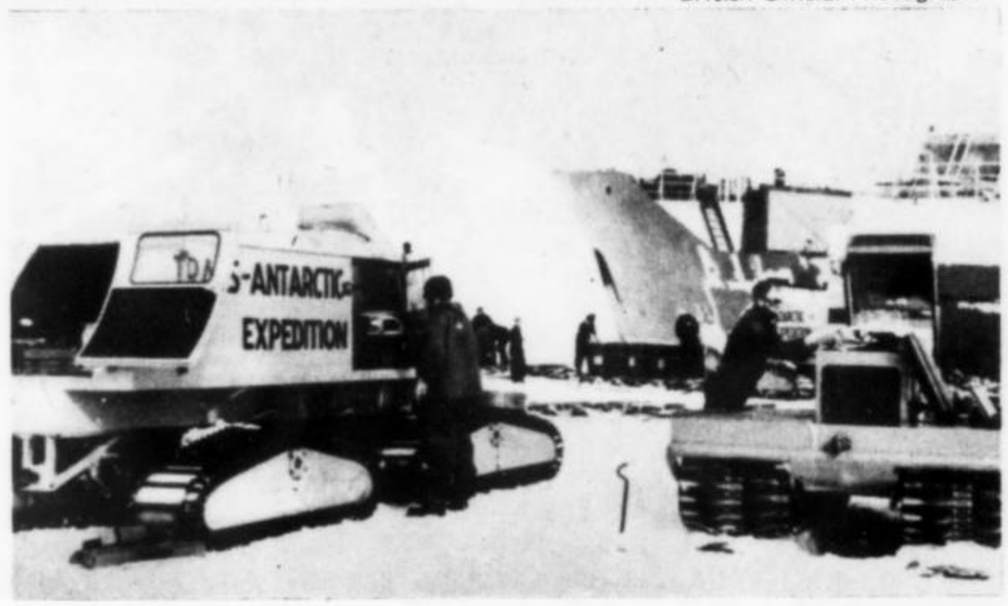
Australian Official Photograph

SECRETS OF ANTARCTICA are now being discovered more rapidly as Nature's resistance is overcome with aid of modern machines such as huge ice-breakers, airplanes, helicopters and electric snow ploughs. Above, Antarctic expedition ship dwarfed by majestic, snow covered mass of Mount Ohlson. Below, right, helicopters for carrying personnel and supplies to advanced bases and tracked vehicles for transporting building materials and instruments have made possible a new era in polar travel though dog teams (below, left) are still of use.

© 1957 Roger Kirschner—French Polar Expeditions

Soviet Antarctic Expedition

British Official Photograph



Australian Official photos

LIFE AND WORK IN AN ICE AGE

Antarctica is the coldest and windiest region of the whole globe—far colder than the Arctic. The air above it lies over a massive continent, glacier-bound, literally in an ice age; and temperatures of 100 degrees F below freezing can result. Surface winds, funnelled down the glacial valleys from the interior can beat north at speeds of 100 miles an hour . These are the rigorous conditions in which men who staff Antarctic weather and other observation stations live and work. Above, howling winds sweep one of research stations maintained on Heard and Macquarie Islands. Below, left, biologist disects a large, red deepsea crab, and right, meteorologist takes instrument readings.

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SIXTH CONTINENT
(Continued)

ODYSSEYS OF THE WHITE WASTES

problem concerns the adjustment of the animals to the extreme cold, the adjustment of their metabolism and the properties of the fats that insulate their tissues. The breeding grounds of the Emperor Penguin and of the seals too are unknown. Both the birds and the seals should be tagged to determine their migrations. Aerial photographs are needed to count their numbers. Their diving habits and underwater life also offer many mysteries. But the geophysicists will have their eyes on the great drama of the skies, the forces of nature and the geologic deeps.

The first man to suspect the existence of the great cold continent was the famous British explorer of the Pacific, Captain James Cook, but his attempts to penetrate the barrier of pack ice failed in both 1773 and 1774. He was within 1,200 miles of the South Pole when he turned back after sailing completely around the continent. It was in 1820 that the land was first clearly seen, either by the American Captain Nathaniel Palmer or by the British Captain Edward Bransfield, both of whom, having sailed south from the South Shetland Islands (500 miles from the tip of South America), saw the mountains of the long north-reaching peninsula. Neither landed. In the same year the Russian Admiral, Fabian von Bellinghausen, sailed half-way around the continent, discovered the large Alexander I Island, and saw vast ice masses which probably were on the mainland.

USIS

It was not until 75 years later, in 1895, that anyone landed on Antarctica and two years later a Belgian vessel, the *Belgica*, first spent the winter in its ice. One member of that expedition, and the first scientist to report on Antarctic phenomena, was the American meteorologist Henryk Arctowski who, at 86, is still living in Florida (U.S.A.). But the first extensive exploration and scientific study was made in 1901 to 1904 by the British National Antarctic Expedition under Captain Robert Falcon Scott which explored the high plateau west of the Ross Sea and reached to within 463 miles of the South Pole. In the same years both a German and a Swedish expedition made scientific studies near the shore.

In the next year, 1905, the American explorer, Robert E. Peary, came within 200 miles of the North Pole and on April 6, 1909, he reached it. But three months earlier, on January 9, a British expedition led by Sir Ernest Shackleton, came within only 97 miles of the South Pole, high on the 10,000 foot plateau, before being forced back by blizzards and lack of food. His failure and Peary's success at the opposite pole led to a second British expedition under Robert Scott which finally reached the South Pole on January 18, 1912. Scott and his four companions perished in a blizzard on the way back but their scientific records and collections were found when Spring came. They were not the first men at the pole. That distinction belongs to a Norwegian party, led by Roald Amundsen, who used dog teams and skis with Norwegian expertness and made a relatively rapid dash to reach the Pole on December 14, 1911—just 35 days before Scott's party arrived there.

Both of Scott's expeditions were sponsored by the British Royal Society and the Royal Geographic Society and produced volumes of scientific observations which were more important, in the long run, than reaching the pole. Simultaneous weather observations were made at widely separated points, which permitted the first weather charts of the region. Magnetic and electrical measurements and the sounding of the upper air also set the pattern for the intensive work that is now to be done by a broad and continuing international effort during the Year.

In 1926 the American aviator Richard E. (later Admiral) Byrd and Floyd Bennett flew from Spitzbergen to the North Pole and return, a distance of 1,360 miles. In April of 1928 the Australian, Sir Hubert Wilkins, flew 2,100 miles from Point Barrow, Alaska, to Green Harbor, Spitzbergen. They proved that there is no continent in the Arctic but they also opened a new era in polar studies. On November 29, 1929, Admiral Byrd and Bernt Balchen flew from their base at Little America to the South Pole and back. The airplane had become indispensable for photographic reconnaissance, for transportation of supplies and personnel to advanced bases and for rescue missions. An American plane landed and returned from the South Pole itself on November 1, 1956, and more than 700 tons of supplies have been landed at the Pole by airlift for the construction of the South Pole Station. The lowflying and slower helicopter is almost equally valuable when operating from shipboard to explore paths through the ice and in landing supplies.

So also the diesel-powered tractor has replaced the dog-team, the ponies and man-power for surface transportation and has made possible the use of immense quantities of building materials, scientific instruments and supplies for comfortable and healthy living. In addition, the power of the ships that must penetrate the ice barriers has grown from the 200 horsepower of Admiral Byrd's first ship only 25 years ago to the modern ice-breaker with ten diesel engines capable of producing 21,000 horsepower. Even more striking is the change effected by radio-communication which permits contact between advance parties and their base, between bases thousands of miles apart, and even with the outside world and home by means of radio-telephone connections. Finally, the science of nutrition has made such advances that scurvy and other deficiency-diseases, once the scourge of explorers, are now unknown. "The Continent is rapidly approaching the period when long-term habitation will become possible", writes Paul E. Siple, the chief scientist at the South Pole Station of the U.S.A.

Ten nations have established bases on Antarctica: Argentina, Australia, Chile, France, Japan, New Zealand, Norway, the U.S.S.R., the United Kingdom and the United States. They are being joined by Belgium, and perhaps Spain. The greatest concentration of research stations, primarily devoted to meteorological studies, is on the long Palmer Peninsula (or Graham Land) which is almost directly south of the tip of South America and of the Falkland Islands. Here the United Kingdom has ten bases, Argentina eight and Chile six, all closely co-operating. Just to the east of it is the Weddell Sea that cuts into the continental shoreline to a depth of some 600 miles and over an east-west spread of nearly one thousand miles.

On its shores are an Argentine base, one of the U.S.A., and the base of the British Royal Society. Almost opposite the Weddell Sea, and thus south of New Zealand, is the Ross Sea which, under its ice cover reaches to within 750 miles of the South Pole. From it, Scott, Shackleton, Amundsen and Byrd all made their famous explorations. On its eastern shore is the main U.S. base, Little America, and to the west, on McMurdo Sound, is the U.S. Air Supply Base and the New Zealand scientific station. At Cape Adare, where the Ross Sea joins the Ocean, is a station that is operated jointly by New Zealand and the United States. Along the coast at intervals westward from Cape Adare are the bases established by France at Pointe Geologie; the U.S.A. on the Knox Coast; the U.S.S.R. at Mirny; Australia on Enderby Land south of the Indian Ocean; Japan and Belgium on the shore of Queen Maud Land south of Africa; and finally the Norwegian station near the eastern limit of the Weddell Sea. The

Cont'd on next page

SIXTH CONTINENT
(Continued)

ICE 5,000 FT. THICK, TEMPERATURES 60 BELOW

Soviet Union, France and the U.S.A. have established stations inland.

The objectives of all the nations are the same: to determine the influence of the Antarctic on world conditions with respect to weather, water balance, glaciers, ocean currents, etc., and to make joint geophysical measurements from this vantage point at the bottom of the world with respect to the earth's magnetism, cosmic rays, the aurora and other phenomena of the upper air and of the earth's interior.

Ambitious Soviet polar programme

THESE objectives are listed in a special report on the Soviet participation written for THE UNESCO COURIER by Evgueni Tolstikov, Deputy Director of the Northern Maritime Route and a Hero of the Soviet Union.—

In undertaking the Antarctic studies, Soviet scientists established a number of projects. Among them are:

1. The study of the influence of atmospheric phenomena in the Antarctic region on the general circulation in the world atmosphere.

2. The study of the basic circulation of the Antarctic waters and its relation to all other ocean currents.

3. Elaboration of the physical geography of the Antarctic and detailed study of its glaciers.

4. Study of the characteristics of geophysical phenomena in the Antarctic.

In accord with these projects and in agreement with the International Committee for the Geophysical Year, the Soviet expedition is planning a series of researches at the Observatory at Mirny and at two stations in the interior, together with two intermediate bases, Pioneerskaia and Komsomolskaia, and the "Oasis" station. Researches for contour mapping will be undertaken by planes and by tractor trains.

A large group of Soviet scientists and specialists will take part in the Antarctic researches in meteorology, atmospherics, actinometry, geology, geography, glaciology, magnetism, seismology, ionospherics, the aurora, cosmic rays, earth movements and gravimetry.

Venture to the 'Pole of Inaccessibility'

SPECIAL structures have been built at the Observatory at Mirny to house modern equipment which will operate on full schedule for the Geophysical Year. At the same time major studies will be made in Antarctic waters by the diesel-electric ship "Ob" and in part by the "Lena," which are specially equipped for a great variety of researches in meteorology, actinometry, oceanography, hydrobiology, maritime geology and geophysics.

While these researches have hardly begun, much interesting information has already been obtained. For instance, measures of the ice at Mirny have shown a thickness of 250 to 650 feet. But under the ice there is no land; beneath is only water down to the sea bottom, 500 feet below sea level. Mirny station is situated partly on some small islands and partly on the ice. It is interesting to note that 60 miles south of Mirny where the surface of the ice sheet gradually rises from the sea to a height of 4,000 feet, the ice has a thickness of 5,000 feet. There too, under the heavy layer of ice, is the bottom of the sea.

Meteorological observations have shown that the area of Antarctica, where Mirny is located is characterized by violent winds. In the course of the year there are 262 days with very high winds and 23 days when the wind was of hurricane strength. These storms are especially frequent in winter. Observations at Pioneerskaia, gave us our first real information on the rigours of the climate in the interior regions. The average temperature of the air in the coldest month is -62°F while that of the least cold month, December, is -8°F. Since there is never a real calm at Pioneerskaia and since the average wind velocity is 20 to 25 miles per hour, it is easy to imagine the difficulties under which the scientists must work in the Antarctic. It must be said, however, that the difficulties and hardships of the men will only be compensated when the scientists of the entire world who are participating in such researches can combine all their efforts. Those of each country taken separately, without the data from the observations of other countries, would not be in a position to solve the problems that are presented by the International Geophysical Year.

The Soviet scientists now maintain continuous radio contact with the Antarctic expeditions of the other countries, mutually exchange the results of their scientific observations, and consult each other on the interesting questions that arise. Such bonds are established with the expeditions of France, Australia, the United Kingdom and the United States. (The stations in the interior, mentioned by Mr. Tolstikov, are to be established at two important points. One is at the South Magnetic Pole which, as in the north, is many hundred miles from the geographic pole. The other is at what is now called the "Pole of Inaccessibility", the centre of the great mass of East Antarctica, the remotest point, about 1,000 miles from the nearest coast).

Robot weather station reports twice daily

THE British programme has many aspects. Largest is the Falkland Islands Dependencies Survey which has been making surveys and polar researches on the islands south of the Falklands and on Graham Land (the Palmer Peninsula) for some years and now operates ten permanent stations in that area. These stations, equipped for the scientific studies included in the Year and especially for weather observations, will lay a firm foundation for the more temporary and often more spectacular ventures around the rim and in the interior of the continent. Argentina and Chile, with 14 stations of their own on the Peninsula, co-operate closely with the British.

Nearer the pole by 600 to 800 miles and on the eastern coast of the Weddell Sea at Halley Bay, the Royal Society has established its own observatory, manned by 18 men, for precision measurements in geophysics and especially for the study of geomagnetism, electrical conditions of the upper atmosphere and radioastronomy. The station lies close to the belt of maximum auroral activity.

Reminiscent of the heroic expeditions of Scott and Shackleton will be the British Trans-Antarctic Expedition and the New Zealand Trans-Antarctic Party, led respectively by Dr. Vivian E. Fuchs and Sir Edmund Hillary, conqueror of Mt. Everest. From Vahsel Bay at the base of the Weddell Sea the British party will climb by track vehicles and dog sled to the South Pole and, continuing, will cross the continent at its narrowest point to McMurdo Sound on the Ross Sea, a distance of about 1,800 miles. The New Zealand party will travel in the opposite direction to a meeting point. This mobile expedition is not primarily scientific, but topographical, meteorological and geological observations will be made and the ice thickness will be measured every 20 to 30 miles.

Australia established a base three years ago at Mawson on the rugged coast directly south of the tip of India. A staff of 24 men is at work with elaborate equipment for the measurement of the aurora, cosmic rays, meteor-tracking to measure winds in the upper atmosphere, geo-magnetic fluctuations and ice-thickness. Mawson base has two airplanes to maintain contact with the smaller Davis base, 400 miles to the east where geological and meteorological

A MAIN STREET CALLED LENIN

Soviet engineers have set up a town site at Mirny ("Peaceful" in Russian) at the foot of the massive Helen Glacier which leads into the interior towards the "Pole of Inaccessibility", the most difficult part of Antarctica. Right, N° 5 Lenin Street, as the main street of the station has been named. An automatic telephone station has been installed in the right wing of the building which is temporarily heated by metal stoves. Soviet preparations for the I.G.Y. in the Antarctic have been going on since 1955 when two ships arrived at the Mirny site and disembarked advance party and stores.

Soviet Antarctic Expeditions

measurements will be supplemented by an all-sky camera. Australia also maintains a station on Macquarie Island a thousand miles north of Antarctica and south of the Australian island of Tasmania. A robot weather station on the Windmill islands automatically reports its observations twice daily by radio to Australia direct.

The United States has established five major stations, plus the station at Cape Adare operated jointly with New Zealand and a station for meteorology and air supply base on McMurdo Sound. The large station at Little America on the eastern shore of the Ross Sea includes 25 scientists and serves as a base for two stations in the interior. One with 9 scientists is at the South Pole; another with 15 scientists is at an altitude of 5,000 feet in the mountains of Marie Byrd Land some 650 miles east of Little America, an 18-day trip by tractor-train. The two others, with 14 scientists each, are on the ice at the base of the Weddell Sea and on the Knox Coast directly opposite, 2,000 miles distant. All five stations are equipped for researches in meteorology, geomagnetism, glaciology, physics of the ionosphere and studies of the aurora and airglow. All except the base on the Weddell Sea ice will undertake seismological research, and the station on the Knox Coast is a major one for studying cosmic rays.

Extensive traverses totalling nearly 5,000 miles will be made from three stations for extended measurements of the ice thickness and the contour of the rocks beneath, measurements of ice flow, of the gravitational field, of magnetic fluctuations and of atmospheric conditions. The station at Little America also operates the Antarctic Weather Central where weather observations are collected and analyses and forecasts are broadcast for the use of all the nations operating on the continent. The station at the South Pole has been named the Amundsen-Scott Base in honour of the only two men who have reached the pole by surface transport. It was dedicated on January 24.

France established a station at Pointe Geologie in Adelie Land, south of Eastern Australia, in 1949-'53 which has again been occupied during the Year together with a smaller station some 300 miles inland toward the South Magnetic Pole.

The Norwegian station east of the Weddell Sea is on the zero meridian of longitude—the meridian of Greenwich—and was established in March 1957.

The Japanese and Belgian stations will be on the relatively unexplored coast that faces Africa, between the Australian base at Mawson and the Weddell Sea, and they complete the ring of stations spaced around the continent. The materials for Japan's station at Showa were unloaded under difficult conditions in February 1957. It is the first Antarctic activity of Japan since 1912 when Choku Shirase made a voyage of exploration.

Belgium is the most recent participant in the Antarctic programme and will make its first entry late this year. The Belgian government has allocated 40 million Belgian francs to the expedition.

As the sun veers southward in September and reappears over Antarctica's northern horizon, the springtime of the epochal Year dawns on the cold continent and a season of feverish activity begins. Before it sets again in March much of the mystery of the Antarctic will have been transformed into sure scientific information and this in turn will solve many a problem in the understanding of the forces that govern this mysterious planet.

SNOWED UNDER AT THE POST OFFICE

Largest part of Britain's I.G.Y. Antarctic activities stems from the Falkland Islands Dependencies Survey which has been conducting both surveys and polar researches in islands south of the Falklands and on Graham Land for some years. It has ten permanent stations in the area equipped for scientific studies included in the Year, but especially for weather observation. Right, Marguerite Bay Base at Stonington Island where eleven British scientists were marooned for over two years. Building with wire-braced chimneys peeping through snow is party's "Post Office".

C.O.I. London

ZERO HOUR (MIDNIGHT) FOR THE WEATHERMAN

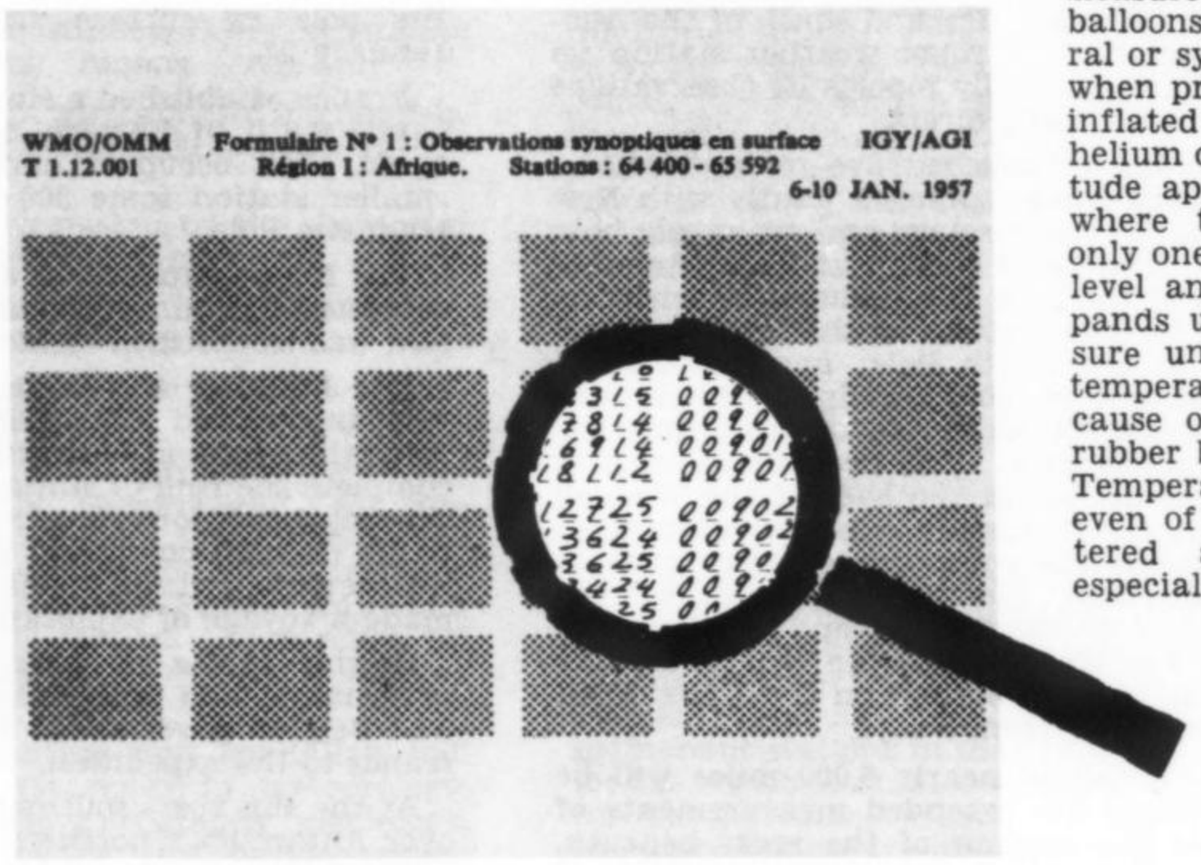
NOTHING is so effective in creating the fascinating human diversity of races, cultures and ways of life as the infinite range of local weather that is called climate, from that of the frozen Arctic tundra to the tropics, from the rain forest to the desert. So the geophysical sciences that touch us most closely are those that study the weather and the climate.

Yet few people are aware that meteorology is not the science of meteors but of weather. It seems a misnomer. However, the word "meteor" comes from the ancient Greek and means "high in the air" and originally included all phenomena above the earth's surface, clouds as well as the aurora and the "shooting stars" to which the word is now limited. And what is more, "climate" has changed its meaning too, for originally it referred only to the incline (which has the same Latin root) of the sun's rays at various locations, whereas now it refers to the relation of the long-range weather to the ground beneath. Meteorology and climatology are the geophysical sciences with direct human appeal, as distinct from the scientific and scholarly.

They are primarily concerned with the lowest layer of air—called the troposphere—which is close to the earth and extends upwards perhaps ten miles. It is warmed by heat radiated from the ground and is compressed by the weight of the air above it—which is about a ton per square foot at sea level. Here and there it is saturated with water evaporated from the ocean which condenses to form visible clouds. It is in constant turmoil, rising upward as it is heated, dropping its moisture as rain when it is cooled, flowing in swift winds where differences of pressure develop, swirling in vast storms a thousand miles in diameter or whistling in violent whirling tornadoes, hurricanes and typhoons when its energy is concentrated. Man has always been at the mercy of the weather and cannot control it. Indeed, it is beyond his understanding because, as has been learned only recently, the circulation of the lower atmosphere is partly dependent on the great winds of the layer above, the cold stratosphere where the air is too thin to support life or even the burning of a candle. Meteorological researches of the Year will thus include conditions in the stratosphere to a height of about 20 miles, as high as weather ballons can rise without bursting. But above that lies the ionosphere, the study of which requires quite different devices and methods, a different committee of the Year, and another article in this issue.

Adequate weather forecasts for a day or two into the future have long been based on measurements and records of the temperature, pressure, humidity, rainfall and the direction and velocity of the wind, taken at weather stations on the land and on ships at sea. The location of existing storm centres was thus established and the direction and speed of their movement could be predicted. But predictions based only on the lowest layer of air, in contact with the ground or sea, were not wholly reliable nor could they extend more than a few days into the future. In recent years weather analyses and forecasts have been based on the movement of major air masses at high altitudes which profoundly influence air circulation at the surface.

For this reason the weather balloon has become an important observing instrument. Many are released as pilot balloons to reach altitudes of five to ten miles where the direction and speed of their drift can be followed optically from the ground stations. Others, called radio-sondes, carry instruments to measure temperature, pressure and humidity which are recorded or reported to ground by radio. A third type is designed to measure wind velocity. These balloons are made of natural or synthetic rubber, and when properly handled and inflated with hydrogen or helium can climb to an altitude approaching 20 miles, where the air pressure is only one fiftieth that at sea level and the balloon expands under its own pressure until it bursts. Low temperature is a major cause of bursting, as the rubber becomes less plastic. Temperatures of -40°F and even of -110°F are encountered at such altitudes, especially in the Arctic and Antarctic, where special weather stations are established for operation during the Year.


WMO/OMM
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Formulaire N° 1 : Observations synoptiques en surface
Région I : Afrique. Stations : 64 400 - 65 592
IGY/AGI
6-10 JAN. 1957

MILLIONS OF OBSERVATIONS will be recorded at the Special Meteorological Data Centre set up by the World Meteorological Organization in Geneva during the I.G.Y. To publish them would require about 1,000 volumes of 1,000 pages each. A cheaper and simple solution has been found in the microcard (above) of less than postcard size on which nearly 50 of the original report forms can be reproduced photographically. Complete collection of meteorological reports received during the I.G.Y. will be compressed into 20,000 microcards.

Obviously data obtained at any one station, no matter how accurate or complete are of little significance until they are combined with data from the entire globe, all of them taken at the same hours and taken every day. Only in this way can the large air masses be identified and their movements followed. Essential to the weather studies of the Year, therefore, is the Meteorological Data Centre operated by the World Meteorological Organization (WMO) at Geneva, Switzerland. WMO is a specialized agency of the United Nations—as UNESCO is—which was established with the purpose of co-ordinating, standardizing and improving meteorological observations throughout the world. It regularly publishes the quarterly WMO Bulletin and for the purposes of the Year has published two authoritative books, one a general survey of the meteorological programme and the other a complete list of the several thousand weather stations of the world that will take part in it. The books can be obtained at WMO headquarters, Campagne Rigot, Avenue de la Paix, Geneva, for 10 and 8 Swiss francs, respectively.

The number of stations that will make weather observations daily at six-hour intervals, beginning at O hours (midnight),

Cont'd on page 18

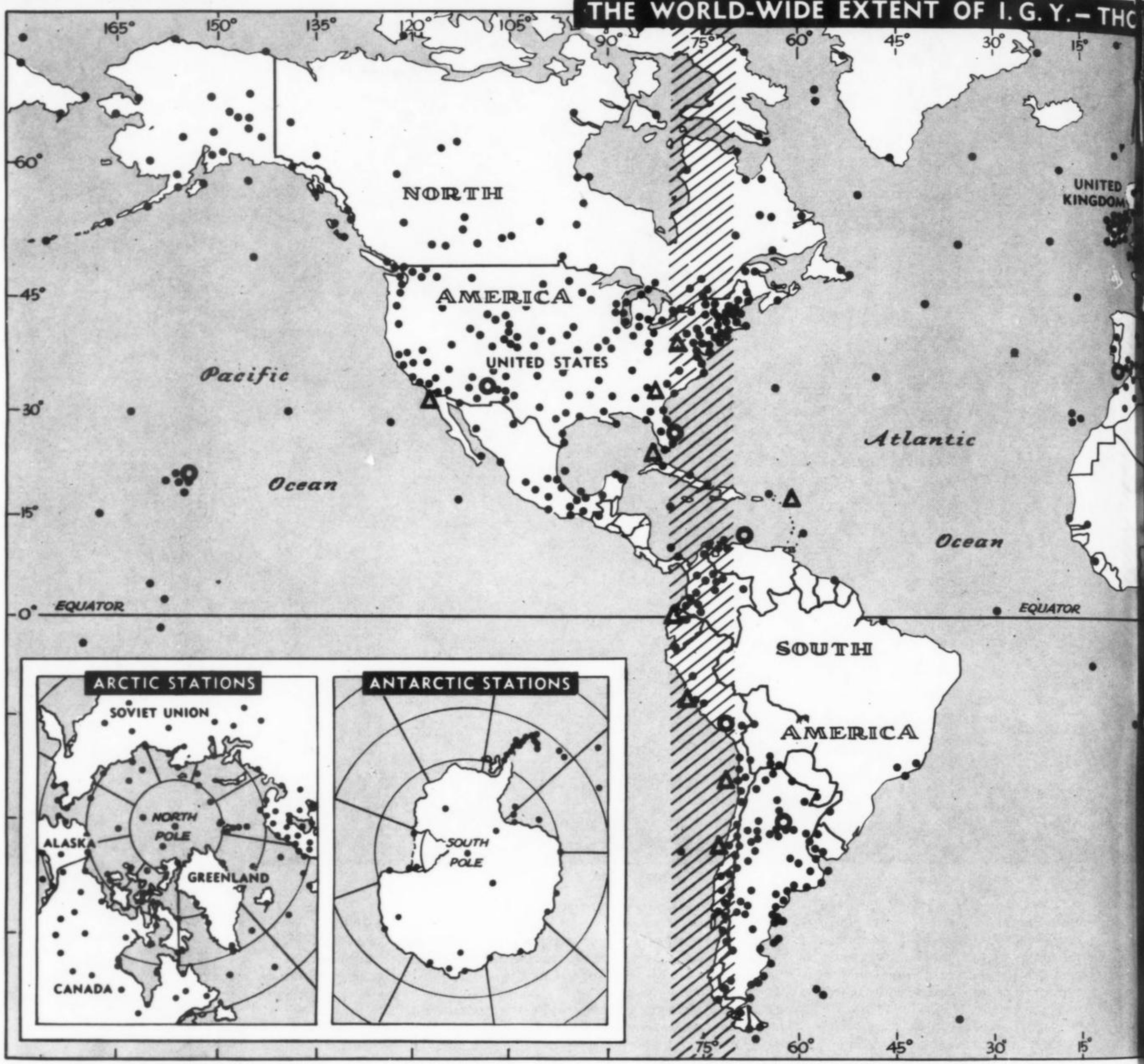
Australian Official photograph

AT WORK ON THE WEATHER. For many years meteorologists have been trying to obtain an ever more complete picture of the global circulation of the atmosphere—knowledge on which really reliable long-range weather forecasting must depend. Much light has been thrown on this problem in recent years through soundings of the upper atmosphere by the radio-sonde—a small radio transmitter which signals atmospheric pressure, temperature and humidity as it is carried aloft by a hydrogen-filled balloon (right). Three hundred additional radio-sonde soundings will be made daily during I.G.Y. Above, observations of extraordinary meteorological phenomena, like this lenticular cloud formation on a storm-swept Antarctic island, help in valuable long-range weather forecasting. Below, left and right, meteorologist analyses weather chart and a radar operator picks up a far distant swirling hurricane on the scope of his set. This new radar equipment will enable meteorologists to study an entire weather front or to magnify and analyse a small portion of an approaching storm.

Meteorologie Nationale, Paris

WMO

USIS



Map courtesy of "New York Times" © 1957

Greenwich Mean Time, is now over 2,100, selected from a much larger number of available stations in order to represent as evenly as possible all areas of the earth. They are located from pole to pole in 93 different countries, and include remote islands in the oceans and ships at sea. There is an especial concentration of stations in five north-south or meridional bands, as shown on world map above.

In addition, some 650 stations are equipped with radiosonde and radio-wind equipment for study of the upper atmosphere. They are expected to carry out two radio-soundings (for temperature, pressure and humidity) and four radio-wind observations daily. A total of 700 stations will also measure the intensity of the radiation received from the sun in terms of direct sunshine, diffuse skylight, long-wave and short-wave (ultra-violet) radiation. Finally, about 100 stations will make frequent measurements of the ozone in the atmosphere at various levels.

This is obviously the most extensive of all the programmes to be undertaken during the Year. It involves many thousands of technical experts and will grind out many millions of individual measurements. These will all be sent to Geneva and coded for reproduction on microcards which can later be studied. It will be some years before the analysis of the cards can distill from them the useful information that may well revolutionize present concepts of atmospheric energy and circulation and may permit more precise long-range weather forecasts .

In scholarly terms the Special Committee for the International Geophysical Year has listed the following major problems to be solved by this study: Redistribution in the atmosphere on a planetary scale of momentum, absolute vorticity, entropy and the various forms of energy.

Large-scale influence of friction and surface topography on the balance of these factors.

Heat and momentum exchanges between the atmosphere on the one hand and the continents and oceans on the other.

Flow patterns in the lower latitudes, including the interactions between the circulations of the two hemispheres and between the tropical and extratropical circulations.

Distribution of precipitation, especially over the oceans and distribution of evaporation at the earth's surface in relation to large-scale world situations.

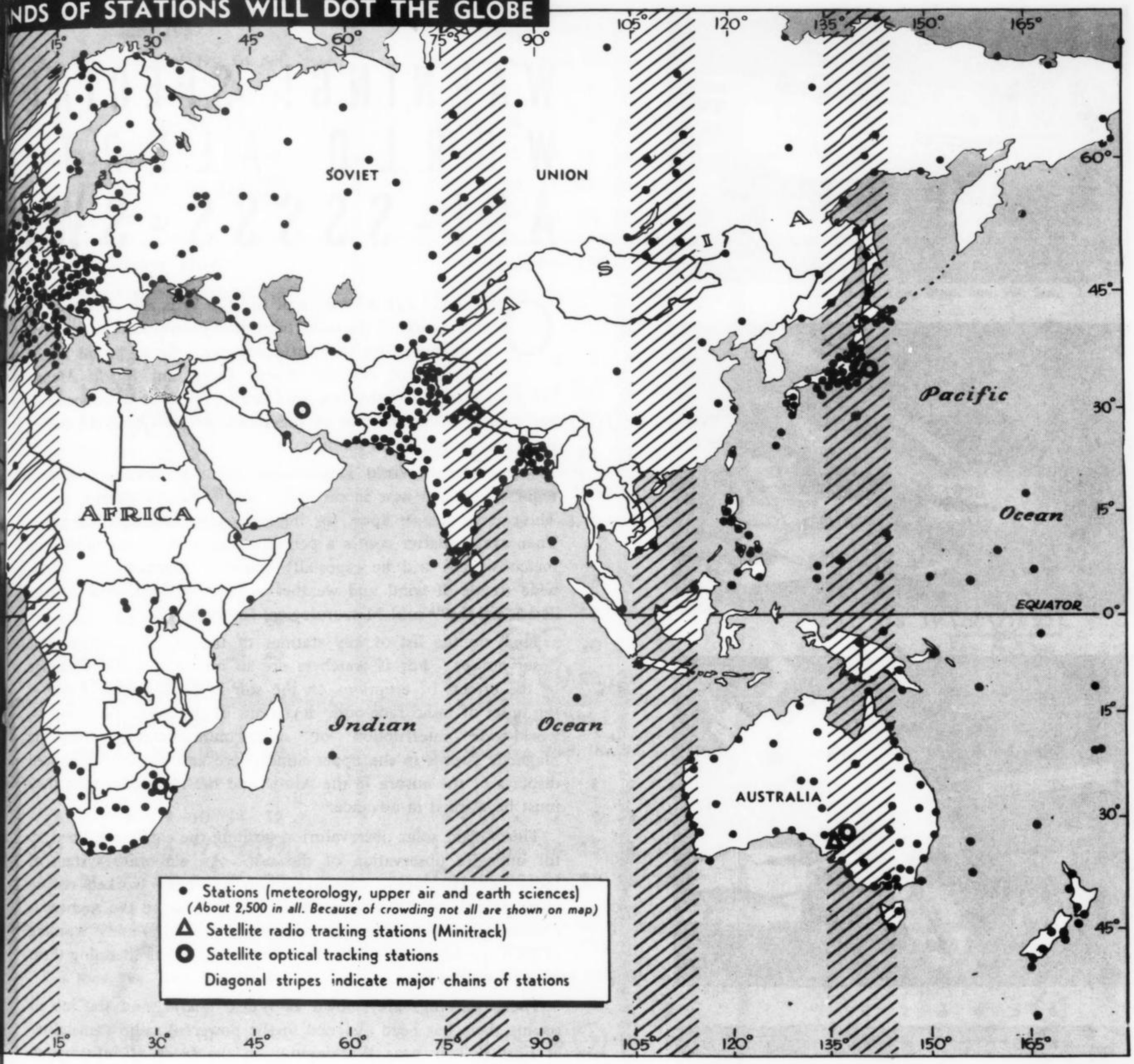
Horizontal and vertical distribution of ozone and of water-vapour.

Heat balance and the radiation balance of the atmosphere in relation to the general circulation.

The electric field in the atmosphere on a planetary scale and its variations in terms of weather systems.

In plainer language, what is involved here is not merely the mapping of the air movements but the transport by the

THOUSANDS OF STATIONS WILL DOT THE GLOBE



air of heat, water, electricity and other forms of energy from place to place on earth, from the hot tropics to the temperate and polar zones, from the upper layers, where sunshine strikes, to the lower, from the oceans to the land. Weather is the result of such transportation and the winds that bring the weather are themselves impelled by air pressure, which represents energy.

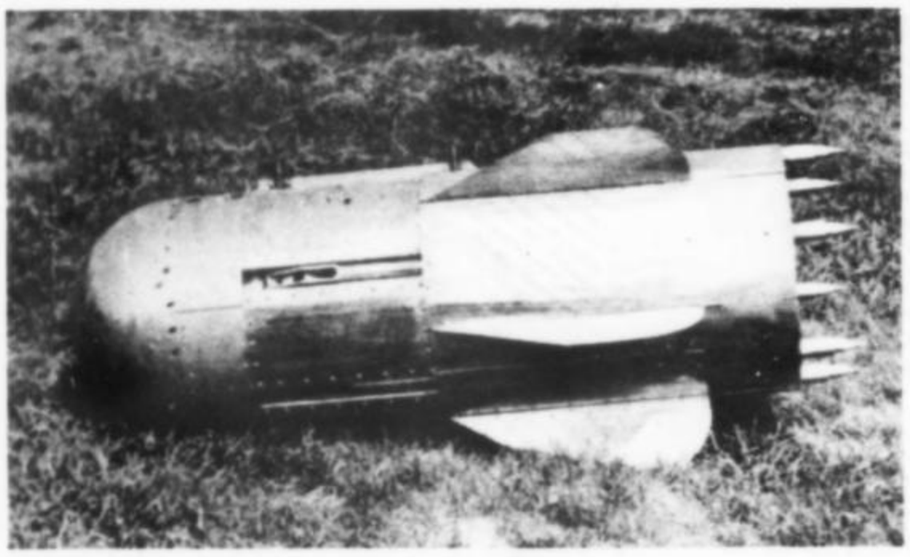
In still plainer language, what is sought is the answer to such questions as: Where and how are the winds generated? What is the origin of the great vortex movements, from rainstorms to hurricanes and typhoons? Are periods of warm and of cold weather related to the energy received from the sun or are they variations in the local energy balance—cold at one point being balanced by heat at another? What is the effect on the atmospheric energy of the vast Antarctic cold area? What is the effect of the temperature of the ocean and of ocean currents? What is the weather map in the stratosphere, where there is no water and no clouds but the winds blow strong, and what is the effect of stratospheric winds on the weather below? Does the earth radiate as much energy into space as it receives from the sun, thus maintaining a balance, or is the earth slowly warming so that the glaciers are melting and the climate all over the earth is changing slowly?

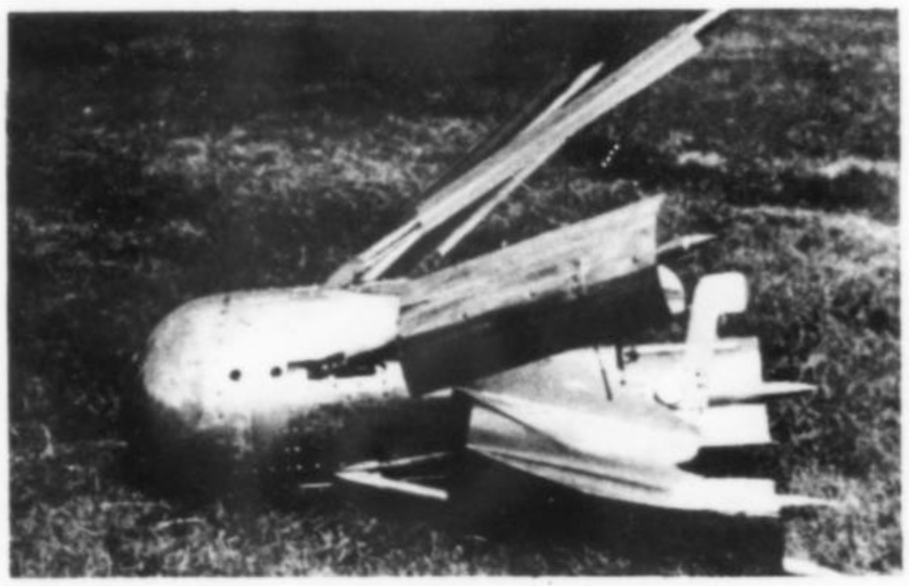
Many of these questions cannot be answered by meteorology alone but involve observations in glaciology and oceanography and especially the phenomena of the upper atmosphere that will be separately studied by means of rockets and the physics of the ionosphere, as detailed in a later article.

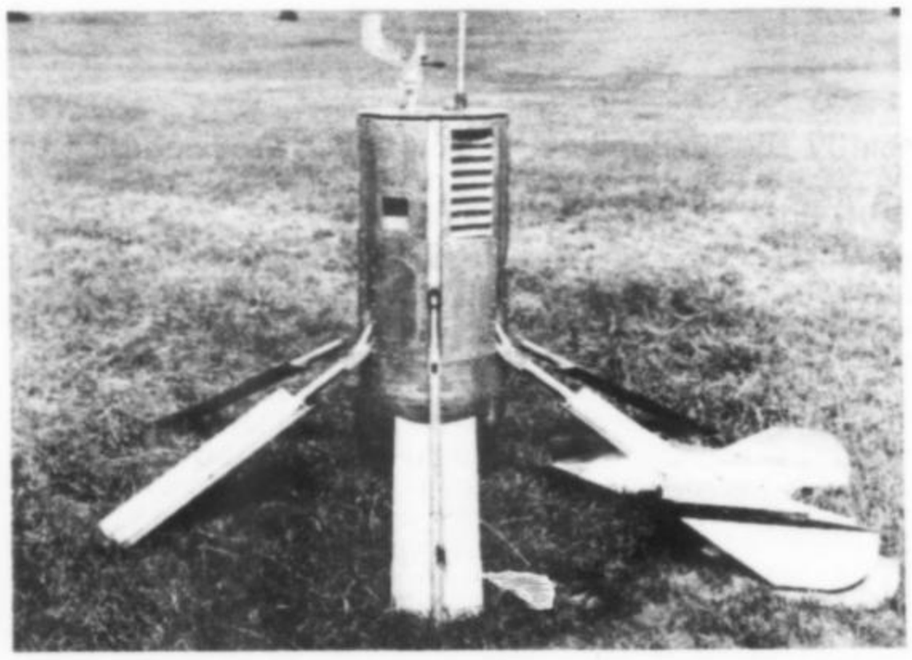
In order to tie together the lower and upper atmosphere observations and to obtain a simultaneous report from different sciences, the Special Committee has established a special calendar for the 18 months of the Year which sets individual days and ten-day periods, known as World Days and World Meteorological Intervals, during which all observations will be increased in number and special tests, such as rocket launchings, will be made. (See pages 20 and 21).

If the occurence of spots on the sun i.e. electrical and magnetic storms, could be predicted, a World Interval would certainly be scheduled for that period because the electrical conditions in the upper atmosphere are then profoundly changed. Sunspots and electrical storms will very probably increase during the Year, however, and provision has been made for a Special World Interval whenever they do appear.

A short article can do no more than sketch the meteorological activities during the Year. Enough has been said to show that the complexity of the investigations will match the complexity of the causes of weather. They are hidden today and as turbulently mixed as the storm winds themselves. This geophysical year promises to unravel most of the confusion and permit much better weather forecasts.







THE GRASSHOPPER, as this robot weather station is called, is dropped by parachute in isolated areas from where meteorological reports would be of greatest value in forecasting the weather. On reaching ground, grasshopper detaches itself from the parachute, erects itself on six legs, takes weather information —wind direction, temperature, barometric pressure and humidity—transcribes these observations automatically into morse and transmits them by radio at a speed of 17 words a minute. It operates on batteries which will power it for 60 days.

WARNING! SPECIAL WORLD ALERT: AGI-SSSSS-SWI

One of the key principles of the I.G.Y. is the *simultaneous* observation of the same or related geophysical phenomena at all points on the world network. So a special I.G.Y. Calendar of *Regular World Days* and *World Meteorological Intervals* (right) has been drawn up so as to concentrate and conserve the energies of the thousands of observers during their long watch of 18 months.

The Regular World Days occur twice a month, two days together at each new moon and a single day at quarter moon. These days are set apart for intensive observation of all kinds. Then every quarter comes a period of ten days during which the meteorologists will be especially active in mapping the world-wide trends of wind and weather at each equinox and solstice. These are the World Meteorological Intervals.

High on the list of key stations of the I.G.Y. are the solar observatories. For if watchers are to obtain a world coverage of the effects of eruptions on the sun in such diverse fields as the onset of radio fade-outs, deviations of the magnetic compass, world-wide interruption of radio-communication following magnetic storms in the upper atmosphere and possibly enhanced displays of the aurora in the Arctic and the Antarctic, then they must be warned in advance.

Thirty-eight solar observatories, girdling the earth, are lined up for intensive observation of the sun. An elaborate system of radio and telegraphic communication has been worked out to give upwards of 800 stations, equipped to observe the numerous phenomena which accompany magnetic storms, timely warning of such special events on the sun, so that scientists manning them may be on the alert.

These warnings are known as *World Alerts,* and the job of issuing them has been assigned to the powerful radio transmitter at Fort Belvoir near Washington, on the basis of information received by radio from Paris, Moscow and Tokio. A team of trained predictors of solar disturbances has been assembled at Fort Belvoir.

A World Alert is issued four to six days ahead of an expected disturbance on the sun at or near the centre of the sun's disc. If the disturbance continues to look important, then the day before its expected advent the Central Warning Service at Fort Belvoir flashes the pre-arranged signal "AGI-SSSSS-SWI", (meaning *Année Géophysique Internationale*—Warning—*Special World Interval*) indicating that a special Interval of several days will be observed.

In this way, observers up and down the world can conserve their energies for periods of maximum solar-terrestial activity, and then go all out towards constructing a real world picture of the event, not only in relation to the geographical map of the world, but also in relation to the events which are taking place high above the earth's surface.

July 1957

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
	1	2	3	(4)	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
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28	29	30	31			

August 1957

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
				1	2	3
4	5	6	7	8	9	10
11	(12)	13	14	15	16	17
18	19	20	21	22	23	24
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September 1957

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8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	(23)	(24)	25	26	27	28
29	(30)					

October 1957

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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27	28	29	30	31		

November 1957

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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10	11	12	13	(14)	15	16
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December 1957

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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29	30	31				

January 1958

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February 1958

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March 1958

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30	31					

April 1958

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(20)	21	22	23	24	25	26
27	28	29	30			

May 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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25	26	27	28	29	30	31

June 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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29	30					

July 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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(27)	28	29	30	31		

August 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
					1	2
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September 1958

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October 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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November 1958

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						1
2	3	(4)	5	6	7	8
9	(10)	(11)	12	13	14	15
16	17	(18)	19	20	21	22
23/30	24	25	26	27	28	29

December 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
	1	2	3	4	5	6
7	8	9	(10)	(11)	12	(13)
14	15	16	(17)	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

World Meteorological Interval

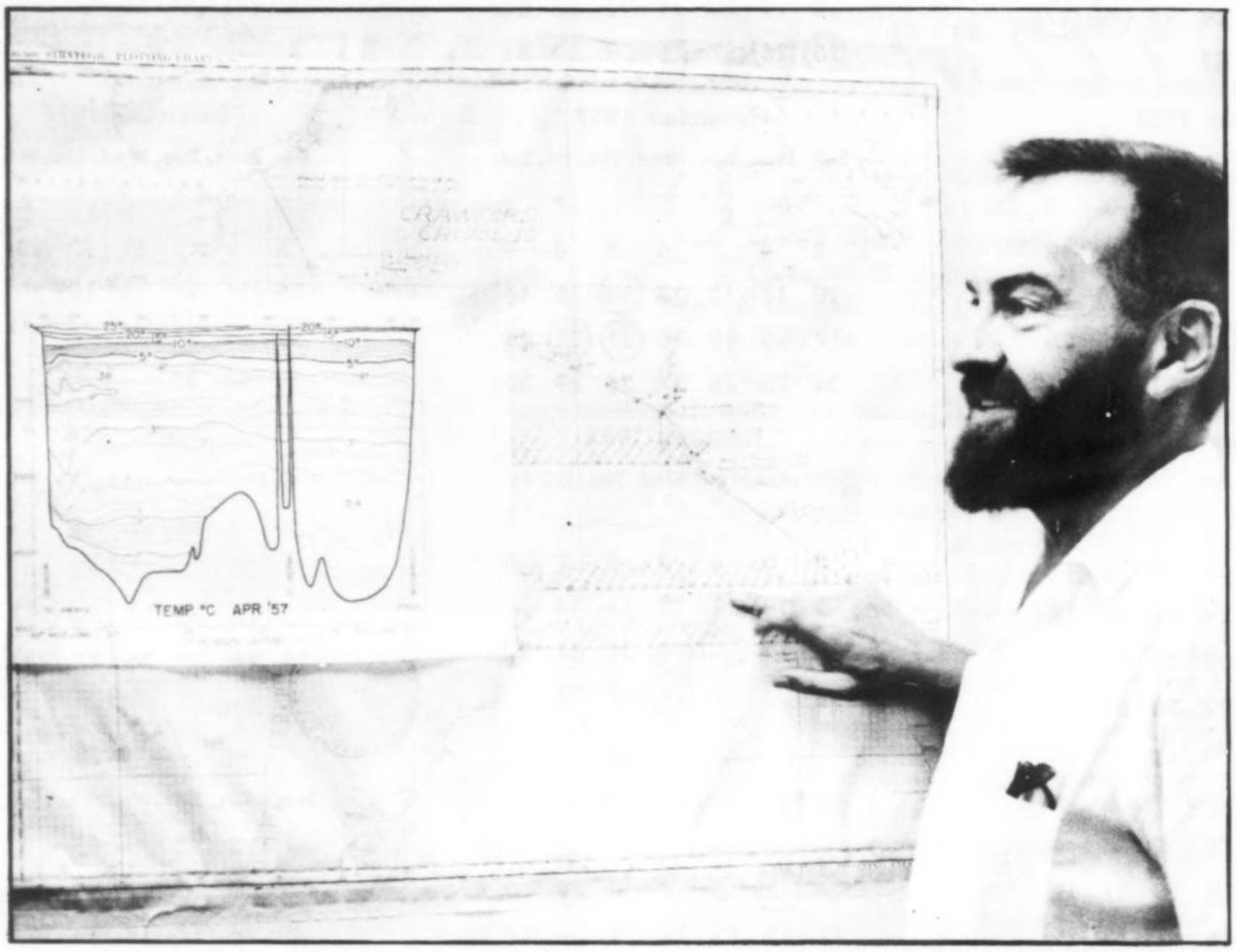
				20	21	22
23	24	25	26	27	28	29

Regular world day (11)
Regular world day at new moon (10)
Unusual meteoric activity 8 (but not world day)

Regular world day with unusual meteoric activity (17)
Day of total eclipse [12]

OUR GREAT OCEAN RESERVOIR

A THOUSAND AND ONE SECRETS LOCKED IN WATER, CLOUDS & ICE



Woods Hole Oceanographic Institute

ANATOMY OF THE ATLANTIC was studied by research ship *Crawford*, from Woods Hole Oceanographic Institute (U.S.A.), in 1957. Here, oceanographer shows vessel's track chart across Atlantic. Superimposed on left is chart of deep-water temperatures between Africa and South America. Island of St. Helena, topping a high mountain peak in the mid-Atlantic submarine range contrasts sharply with depths of 15,000 feet surrounding it. At this latitude bottom waters are close to freezing point and only in top 200 metres are ocean waters near the temperature of the atmosphere.

The immensity of this earth is best appreciated by the men of the sea. From the air it seems small; on the land the expanse is always limited. But the sea is continuous and endless. The continents are only islands in it. Altogether they cover only 57 million square miles. But the ocean area is 140 million square miles—two point five times the land area. And ten percent of the land, six million square miles, is covered with ice that is slowly crawling back to the sea. Almost three quarters of the earth's surface is water or ice.

The volume of water, is even more impressive. In human terms a cubic mile is enormous, for a box one tenth of a cubic mile in size could easily contain the entire human race—though not comfortably. Yet a cubic mile would hardly seem a drop in the world's total of 350 million cubic miles of water. While most of the water is in the great ocean reservoir, of course, about 25 million cubic miles of it is in circulation elsewhere at any moment, making the grand tour up into the skies by evaporation, then falling as rain or snow and returning to the ocean via the rivers. The atmosphere probably contains about 3,600 cubic miles in the form of vapour and clouds. The surface rivers and lakes hold about 55,000 cubic miles. The amount hidden in underground rivers and reservoirs is several hundred times larger and has been estimated at 20 million cubic miles.

But aside from all these mobile forms, there is still about one percent of all the earth's water that is detained in its circuit, frozen, perhaps for centuries, in the form of glaciers and the massive ice cover of Greenland and Antarctica. How much this is nobody knows because the thickness of the Antarctic ice has been measured at very few points. Estimates of the average thickness vary from 2,000 to 5,000 feet but at some points it is certainly 10,000 feet thick. One of the most interesting results of the Year's researches will be the answer to this question. Depending on the thickness, the total volume of Antarctic ice is between 2.4 million and 6 million cubic miles.

If all this ice were permanently frozen in place, it would matter little to human thought or plans. But it is in constant exchange, always growing with snowfall yet always flowing to the sea in glaciers or breaking from the Shelf Ice as icebergs and in sheets that may be several hundred miles in extent and hundreds of feet thick. Part of the snow is blown to sea by high winds. Above all, a rise in temperature causes melting. If it were all melted and ran to the sea the level of the oceans all over the world would rise by 60 to 200 feet. Most of the world's great seaport cities would be inundated. A report to the American Geophysical Union calls the Antarctic glaciers "something of a Sword of Damocles hanging over the heads of all peoples living close to the sea".

It could happen but not soon and only very slowly—conceivably in 10,000 to 20,000 years. In fact, during most of the world's history the earth was probably free of glaciers. But in the past million years there have been four great ice ages when the average temperature was some ten degrees cooler so that ice accumulated and

covered a million square miles each in Europe, Siberia and North America. As the ice piled up on the land, the level of the sea dropped to some 300 feet lower than now.

In about 3,000 B.C. the climate was warmer and drier than now and sea level was apparently about six feet higher than now. Then the glaciers grew again and reached a maximum in the 18th century. Since then the glaciers have been receding and the sea level is rising at a rate of about 2.5 inches per century. Since the temperature of the earth is variable, the glaciers come and go and even the "ageless and eternal sea" rises and falls again. Man is powerless to control such vast forces but he has the ability to understand them and to foresee their effects. This is part of the task of the sciences of glaciology and of oceanography during the Year.

Accordingly the Antarctic studies during the Year join with those in the Arctic and with glacier studies throughout the world to determine the life history of the ice, including its rate of formation, its age, and the shifting balance between its growth and its melting. Extended studies are under way by both Soviet and American scientists encamped on floating ice islands to measure their drift and observe their fate as well as to measure the temperature, depth and circulation of the Antarctic and Arctic seas.

★

As for many years, since 1912, the International Ice Patrol will continue its investigation of icebergs in the North Atlantic for the direct benefit of merchant shipping but also to obtain weather data. So glaciology, oceanography and meteorology merge their surveys of ice, water and clouds for the purposes of better forecasting of oceanic conditions and especially of anticipating their changes in the course of years.

Oceanography itself is a many-sided science that includes the geological study of the sea bottom and the geography of its submerged mountain ranges and deep trenches, the variation of the saltiness, chemical composition, and temperature of the waters, the mapping of the great movements of the ocean currents both at the surface and in the deeps, and the study of marine life, both plant and animal, polar and tropical, at the surface and in depth. During the Year, however, it is the ocean itself that will be especially studied, not its life.

The surface currents of the oceans have a direct effect on the climate and the weather of the continents as the warm tropical waters flow toward the poles, both north and south, and are driven eastward both by winds and by the rotation of the earth. Thus the Gulf Stream in the Atlantic and the Japan Current in the Pacific warm the western areas of both America and Europe.

But cold water from the Polar regions flows toward the tropics in the ocean depths. The British research ship *Discovery II* has recently tracked the deep currents by using a float made of sealed aluminium tubing which is heavier than water at the surface, but can be adjusted to the density of the compressed seawater at any depth and can be effectively suspended at different underwater levels. It drifts with the submerged currents, sending out sound signals which permit the ship to follow it on the surface. In the Gulf Stream there is a strong northward movement at the surface and little movement at depths of 5,000 to 6,000 feet, but at depths between 8,200 and 9,200 feet the movement is southward. At one point the deep float travelled 23 miles in 66 hours. Even 18 inches from the bottom there is noticeable flow to the south.

Thus the ocean "turns over" at a slow pace. The complete top-to-bottom exchange may take from 150 to 1,000 years, bringing the surface plant life to the lower levels and mineral nutrients to the top. It is possible that the fluctuations may be responsible for severe changes in the climate on land. The "age" of the deep waters—i.e. the years since they were at the surface—is measured by bringing up samples from far below, releasing its dissolved carbon dioxide by means of acid, then determining the ratio of the three forms, or isotopes, of carbon in the gas. As the radio-active isotope gradually disappears with the years, the ratio shows how long each sample has been submerged.

Knowledge of the deep currents will also become increasingly important if the practice of disposing of radio-active wastes from nuclear power plants becomes general in the atomic age. It is by no means certain that such materials will long remain where they are dropped. So it is also important to know the nature of the ocean floor. It has usually been assumed to be a thick layer of sediments but there are certainly large areas of bare rock. Samples are gathered by dropping a core-tube to within a few feet of the bottom, suspended on a heavy cable, then releasing a heavy lead weight which drives the core-pipe into the soft sediment. With a

Cont'd on next page

Woods Hole Oceanographic Institute photos

'AGE' OF OCEAN WATERS at great depths—the years since they were at the surface—can now be measured by studying content of radio-active isotopes to determine the "turn over" or complete top-to-bottom exchange which may take from 150 to 1,000 years and whose fluctuations may be responsible for severe changes in climate on land. Above, right, lowering a water sampler from U.S research. ship, *Crawford*, to obtain specimens from the depths. Thousands of observations of temperature, salinity, oxygen content etc., will be made during the I.G.Y. by ships of many nations. Above, left, technician unhooks a "Nansen bottle" used for collecting submarine water.

OCEAN RESERVOIR *(Continued)*

tube, about 3 inches in diameter, samples 100 feet in thickness have been obtained but more recent devices take wider samples of less thickness. Columbia University's research vessel, the *Vema,* has taken samples from the ocean bottom 13,000 feet beneath the surface. Microscopic study of the materials in the samples and of their arrangement in depth reveals their geological history.

Another ocean-bottom device measures the heat that flows to the sea from the relatively thin crust of the earth under it. Because of the vast extent of the oceans this is an important element in the heat balance of the earth. It is the only major source of energy that does not originate on the sun.

★

THE largest task of the oceanographers is to map the geography of the sea bottom over its entire area, which is 70 percent of the area of the earth. It is not flat but, like the land area, has long chains of high mountains, most of them wholly submerged though some extend above the surface as islands in the sea. There is one such range 8,000 miles long, running north and south in the Atlantic between Europe-Africa and the two Americas. Its peaks are 10,000 feet above their base on the Atlantic floor. Another such ridge runs from Japan south to Antarctica and that continent is also joined to South America by an undersea ridge which projects above the surface to form the South Sandwich, South Orkney and South Shetland Islands. But there are also long deep trenches that cut into the sea bottom to a depth of several miles. The deepest is southwest of the island of Guam, more than 34,000 feet below sea-level at the lowest point yet measured. If the earth's highest mountain, Mt. Everest in the Himalayas, were based on this trench, it's summit would still be 5,000 feet below sea level.

Large areas of the sea, however, have not been mapped and surprises may appear during the Year as vessels of many nations continue with the modern technique of echo-sounding which measures the depth by the reflection of sound-waves from the bottom. Earlier this year, for instance, the Lamont Geological Observatory of Columbia University announced the discovery of a "rift" in the sea-bottom that is 45,000 miles long and coincides with the major undersea earthquake zone along its entire length. It averages 20 miles in width and 7,500 feet in depth. It is bordered by mountain ridges that average 6,000 feet in height and about 75 miles in width.

The sea is the source of all rain and no certain understanding of the world's weather is possible without much better knowledge than is now available of the controlling factors in the sea. The relatively unspectacular explorations of the ocean deeps, showing only a white research yacht slowly cruising along, far from the major traffic lanes, are nevertheless one of the most important features of the Year.

UNESCO AND THE I.G.Y.

THE Department of Natural Sciences of UNESCO has no laboratories, observatories or scientific equipment, conducts no researches, and cannot take an active part in the Year. Its function is to advance world science, primarily by means of existing international scientific organizations such as the Scientific Unions that are organized into the International Council of Scientific Unions and the International Council of Medical Sciences. It stimulates international co-operation in the attack on problems that are regional or world-wide. For example, its Advisory Committee on Arid Zone Research has effectively unified the programmes of the 37 nations that are handicapped by deserts or arid lands. Humid tropics, marine biology and the use of radio-isotopes are similar projects.

UNESCO has for the past ten years allocated an annual subvention of around $180,000 from its own limited budget to support the meetings and the headquarters of the International Council of Scientific Unions (I.C.S.U.), which are now in London (1). The council established, the Special Committee on the International Geophysical Year which did its original organization and planning partly on subventions from UNESCO, listed below (larger funds were later supplied by many other scientific organizations and governments):

$1,400 for the organization of the first meeting of the Committee at Brussels in October, 1952.

$1,000 for the first preparatory work on the Year in 1953.

$2,000 for the second meeting of the Committee at Rome, October 1954.

$20,000 for the establishment of the permanent Committee headquarters, for the work of the Committee and maintenance of its headquarters in 1955.

$15,000 similarly for 1956.

$50,000 for the biennium 1957-58.

However, education in science is also an important UNESCO function. This issue of THE UNESCO COURIER, devoted to the International Geophysical Year, is only one aspect of UNESCO's educational support. Another is the newest of UNESCO's famous travelling science exhibitions, dedicated entirely to geophysics and to the scientific activities of the Year, which will tour almost the entire globe in 1957 and 1958. These exhibitions are enormously popular educational displays that travel from country to country at the invitation of the member states of UNESCO.

UNESCO's international fellowship training programme in science has also provided and financed eight fellowships to augment the supply of competent experts needed by the Year's widespread activities. Fellows have been appointed from Argentina, Bolivia, Chile, Egypt, Pakistan, Peru, Thailand and Yugoslavia. They have been in training during the past year at the Institute of Meteorology, Charlottenlund, Denmark; The California Institute of Technology; The U.S. Weather Bureau, Washington; The U.S. National Bureau of Standards, Washington; The University of Colorado U.S.A.; The U.S. Coast and Geodetic Survey; The Carnegie Institution of Washington. In addition to the grants made by UNESCO, the Special Committee for the International Geophysical Year has received annual grants from the I.C.S.U. since 1952, and more than ten countries have made individual contributions varying in size from several hundreds to several thousands of dollars.

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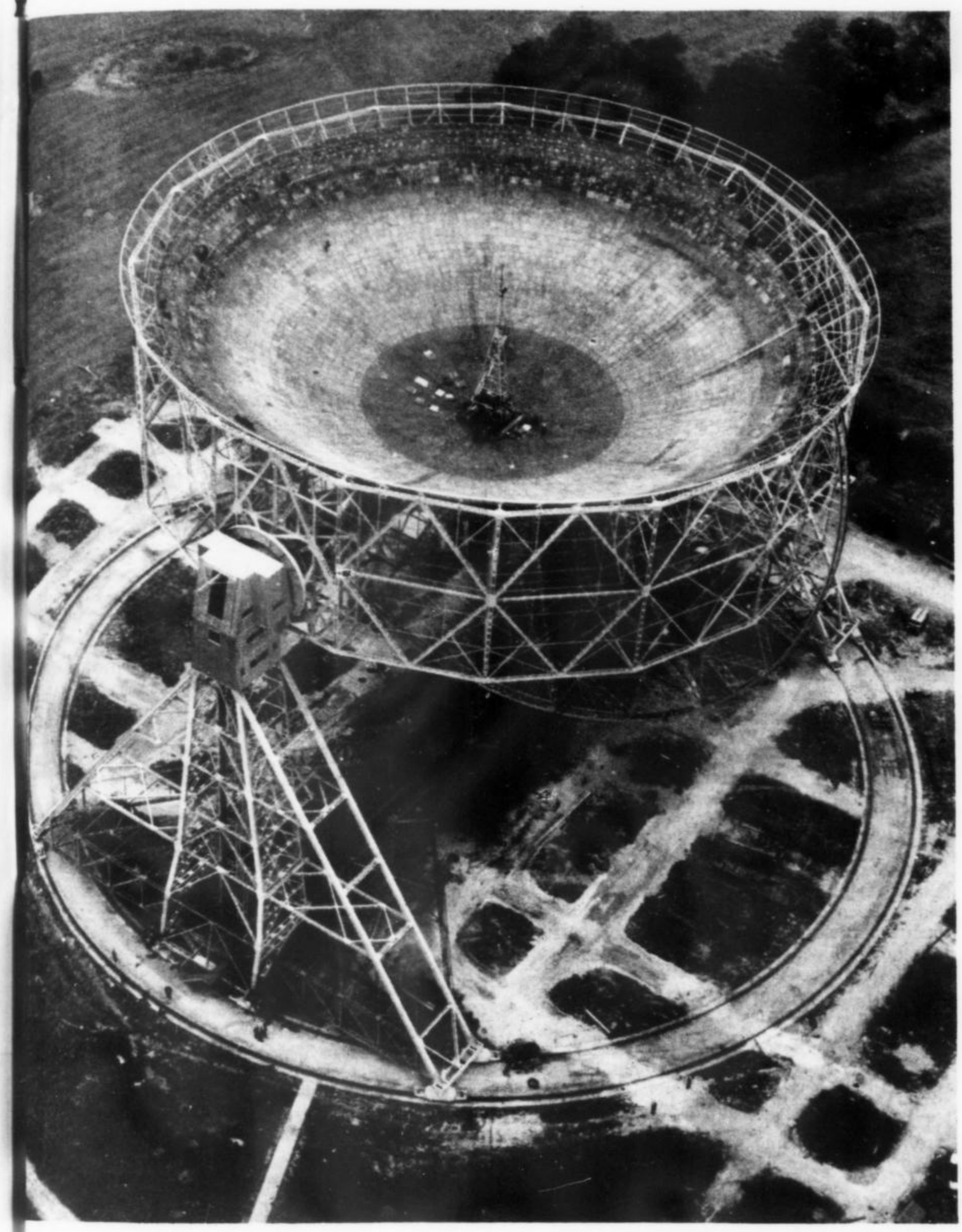
(1) The members of the International Council of Scientific Unions are: International Astronomical Union; International Union of Biological Sciences; International Union of Pure and Applied Chemistry; International Union of Crystallography; International Union of Geodesy and Geophysics; International Geographical Union; International Union of the History and Philosophy of Science; International Union of Theoretical and Applied Mechanics; International Union of Pure and Applied Physics; International Scientific Radio Union; International Mathematical Union; International Union of Physiological Sciences; International Union of Biochemistry.



A GIANT EAR 'LISTENS IN' TO THE STARS

Radioastronomers at Jodrell Bank, Cheshire, England, have begun delving into the secrets of outer space with the giant, 250-foot, dish-shaped radio telescope (left) completed recently for Manchester University after five years of construction.

Designed to explore natural radio signals coming from outer space, the radio telescope will enable scientists to "listen in" to cosmic events that took place millions of years ago and to reach out into space to distances of 1,000 million light years or more—far beyond the limits of observation of the greatest existing optical telescopes.

The mammoth radio telescope (total weight 2,000 tons) went into operation in August, and Professor A.C.B. Lovell, professor of radioastronomy at Manchester University, who is in charge of it, reported that in two hours it provided information that would have taken a month to collect with any previously existing receiver. After these initial tests, the new telescope will play a part in Britain's contribution to the I.G.Y.

Pressure on a series of buttons brings this enormous mass of steel into action, slowly, almost imperceptibly (maximum speed one mile per hour) sweeping the heavens while following a star in its course. Electronic computors do all the calculations required to keep the 62 ½ foot aerial inside the bowl pointing at the star wherever it moves in the sky, taking into account the movement of the earth around its axis and around the sun.
Originally designed to survey unknown parts of the sky by intercepting the faint radio signals emitted by celestial bodies like the stars, the sun and distant galaxies, the radio telescope will also be used during the I.G.Y. to send radio pulses to the planets and the moon and receive the echos that "bounce" back. By 1960 with the aid of this instrument scientists will have learned a great deal about conditions that existed in the universe millions of years ago.

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WHERE THE SKY IS BLACK

THERE is an eerie fascination in the high ionosphere. It is 50 to 250 miles above the earth, higher than man ever dreamed of reaching until the recent development of rockets. Nothing can live there because the air is too thin—only one ten-millionth as dense as on the earth. There can be no sound. The sky above is black because there is nothing to break up and reflect the sun's rays. But the black sky glitters with brilliant stars, and the sharp beam of the sun—if one could look at it—would burn like a rod of white-hot metal, yet is embroidered with graceful solar flares and the shimmering lace of the corona.

The aurora is ever present, by day as by night, weaving electronic rays into gorgeous designs over the poles, waving majestic draperies of light hundreds of miles high and thousands wide. Millions of meteors from the depths of space flash into burning dust on all sides, like fireflies on a Spring night. Unseen and unheard is a turmoil of radio waves from distant stars and from clouds of cold gas between the stars. And finally cosmic rays, projected from unknown explosions somewhere deep in the black sky, pierce through any obstacle only, sooner or later, to crash head-on into the nucleus of some lone atom and thereby create a whole shower of secondary rays that repeat the collision miles and miles below as they, in turn, dash earthward.

There in the black ionosphere is the drama of cosmic energy, variegated and manifold, impinging on the tenuous halo of the earth, with no man to see it. But the irresistible fascination is that without being there, without the supersenses that would be needed to detect these rays and radiations, man nevertheless can know them through the instruments he devises and the mathematics that makes them subject to reason.

C. T K. Bratislava

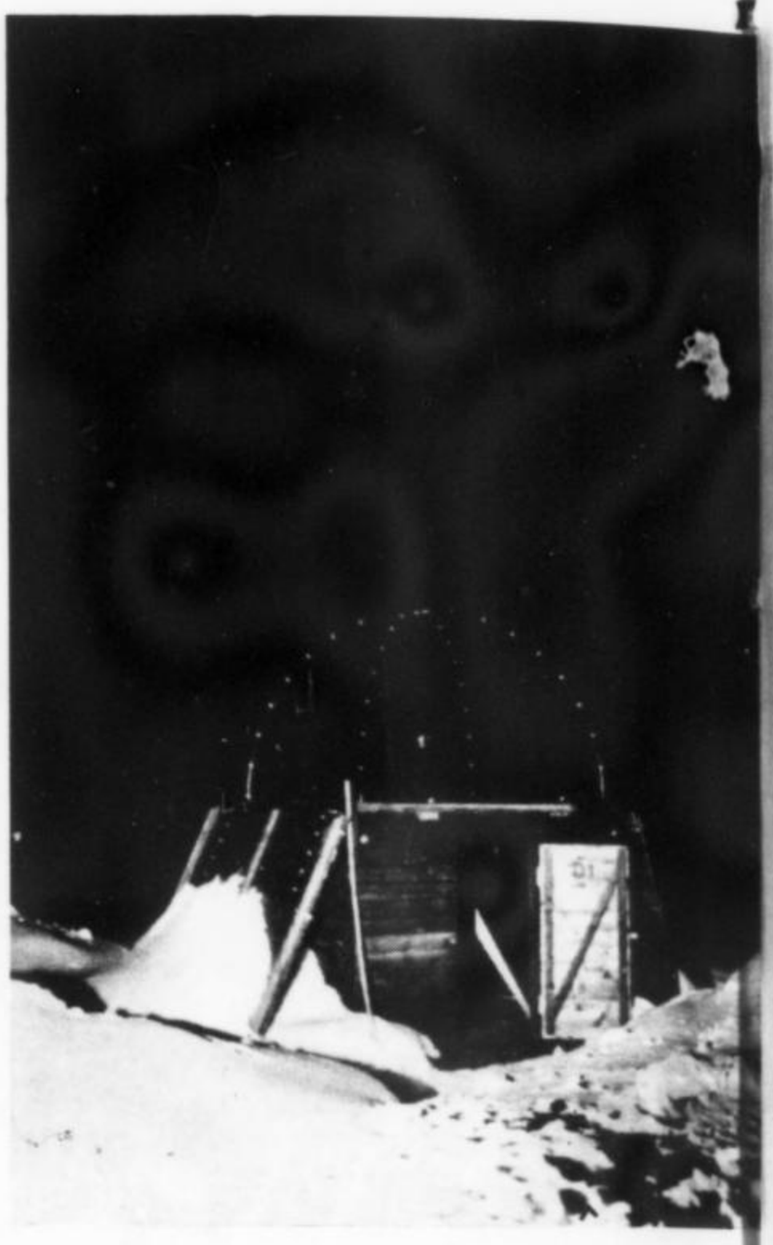
MOUNTAIN OBSERVATORY in the High Tatra range, Czechoslovakia, is making special cosmic ray studies for I.G.Y. Another observatory is perched on Mount Lomnitze (8,000 feet high) seen in background. Cosmic rays are also being studied in Central Europe's deepest mine, at Pribram, Czechoslovakia.

The first inkling of all this complexity came when it was discovered that radio waves are reflected from something in the sky so that they do not escape into space when they pass the horizon but bounce down again to reach distant receivers in spite of the curvature of the earth. A simple measurement of the time required to reach the reflector and return to earth showed that the reflecting layer is 60 to 90 miles above the ground. This discovery, made in 1925, explained how wireless messages can be sent across the ocean and made possible the sending of radio broadcasts beyond the horizon. It also proved that there is an electrified layer in the thin air at that height which contains free electrons that are set into oscillation by the radio wave. It absorbs the energy of the wave so that it does not pass on but the electron oscillation generates the same wave-length and part of the new wave returns to the ground.

This simple mechanism of reflection means that large numbers of free electrons and of electrically charged molecules, called ions, are present in the upper atmosphere. It is now known that there are three major layers of ionized air which reflect radio waves of different frequencies. The one mentioned is known as the E layer. Above it, at a height of about 90 to 150 miles, is the F-1 layer and still higher is the F-2 layer. The E-layer normally has 120 electrons per cubic millimetre, the F-1 layer 220, and the F-2 layer 450. Ions are therefore the outstanding characteristic of the upper atmosphere so that it is properly known as the ionosphere.

Storms in outer space cut world communications

THE ions are formed by the detachment of electrons from atoms and molecules of ordinary oxygen, nitrogen and other gases in the air when they are bombarded by radiations from the sun, by particles from outer space, even by passing meteors. The chief source is the ultra-violet light from the sun which is intense at that height but never reaches the surface of the earth itself. The number of ions at any moment is therefore dependent on the amount and the type of radiations received from outside the earth. Thus the ionosphere is a sort of sensitive skin for our planet, receiving and responding to external influences. And because the ionization can be observed from the surface, by radio reflection, by radar, and often optically too, it acts as a sort of relay station to report external events to puny men far below on the ground whose senses are inadequate but whose instruments, added to those senses, can feel the skin of the planet and can thereby learn what goes on hundreds of miles high in the sky at the spherical border of space. This is the function of what is



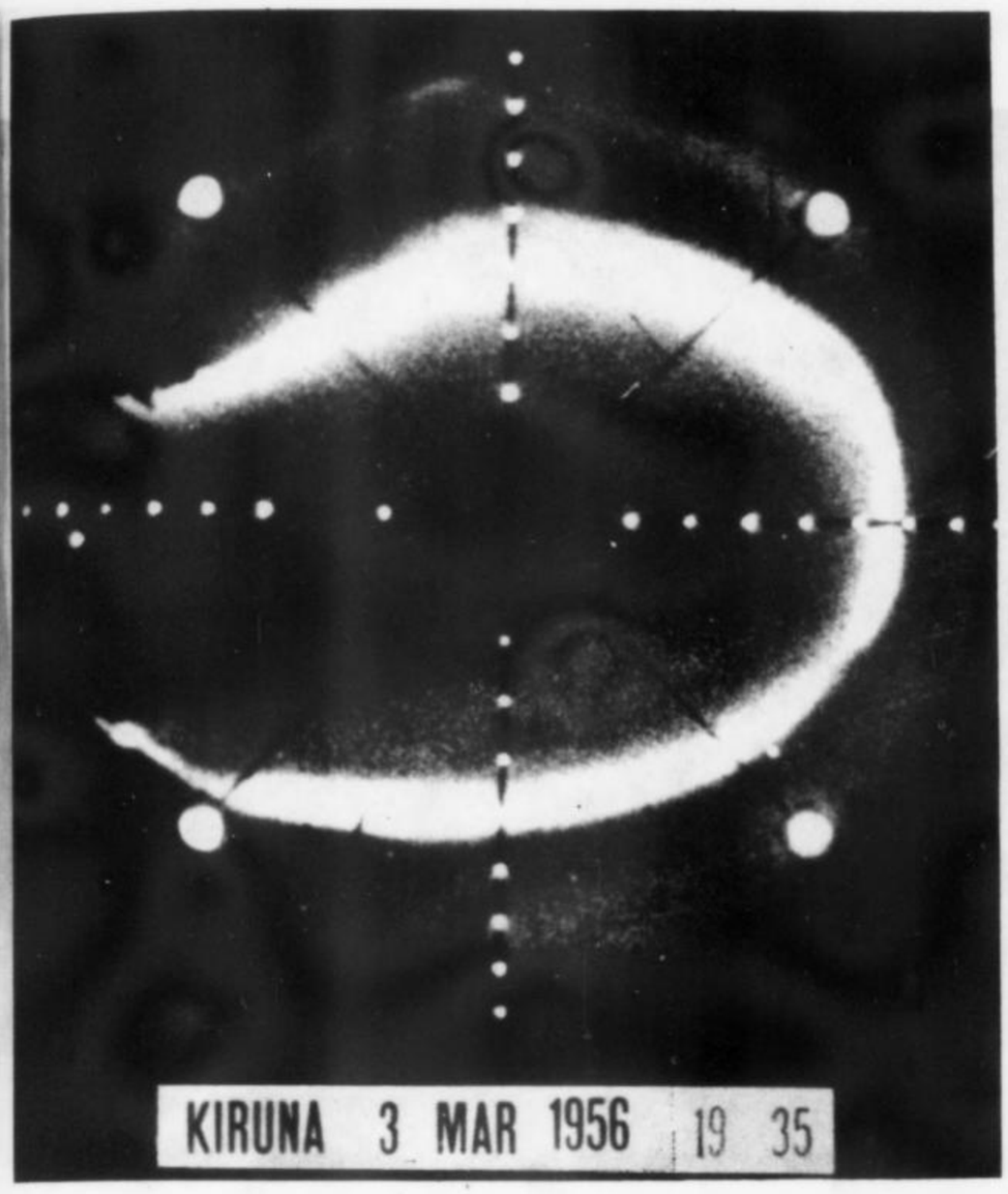
AURORA BOREALIS

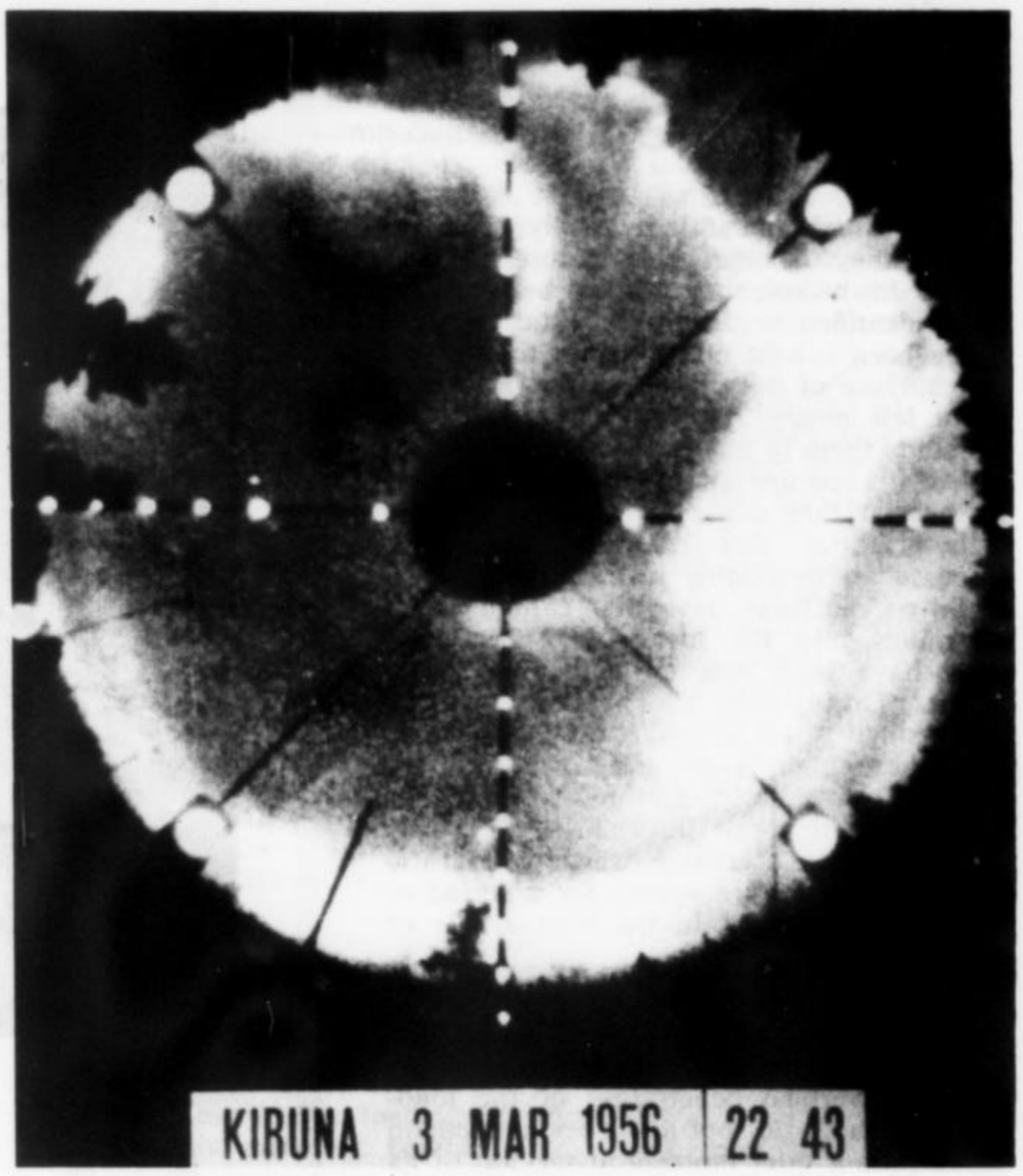
called the physics of the ionosphere, one of the major activities of the Year.

Below the ionosphere is the stratosphere with air dense enough to support radiosonde and other light balloons. The highest unmanned balloon has risen to about 30 miles. This is the frontier of weather studies, as described in another article in this issue. Recent rockets have entered the ionosphere but none has as yet gone through and beyond it. But above the ionosphere is the unknown exosphere where even ions are few and far between. This will be the playground of the artificial satellite, careering freely through space by virtue of its velocity and held captive only by gravitation, the one earthly force that extends outward without limit.

The ionosphere is restless, more so than any layer below, more restless than the sea, because its ions are sensitive and very light. It rises and falls in majestic tides with the passage of the sun and the moon. The ionization grows by day and wanes by night as the sunlight comes and goes. It is stronger in winter than in summer. A passing meteor may increase the ionization locally a thousand-fold, as is described in an article that follows. Each of these has its effects on the transmission of wireless messages and of radio broadcasts. But still more impressive are the major turbulences that are known as storms. They may be real storms in the sense of violent, high-altitude winds. They may be responses to storms on the sun which spew out vast fountains of swift particles and put the ultra-violet radiation into spasms. Certainly the ionization is affected by the solar eruptions that cause the aurora borealis and the aurora australis (Northern and Southern Lights) and it varies regularly with the eleven year cycle of sunspots.

A consequence of all this turmoil on high is the variation of the magnetic field





was photographed at Kiruna, northern Sweden, by all-sky camera (above, left) which took in auroral displays from horizon to horizon by means of curved mirror that reflects sky's image onto film. Small white dots above camera are pilot lights which determine aurora's position in both azimuth and altitude. During I.G.Y. observing stations will be clustered for the first time about both magnetic poles in zones of maximum auroral activity.

Photos courtesy Uppsala Ionosphere Observatory, Sweden

of the earth and the "magnetic storms" on the surface which disrupt even ordinary telegraphic and telephonic communication. This is presumably because a layer of ions is a conductor of electricity and a movement of ions is an electric current. Every electric current generates a magnetic field, whether it flows in a wire or flows free. So ionospheric winds could well produce enough magnetism to magnify or counteract the earth's own magnetism or to change its direction somewhat, and thus to affect every compass on every ship and plane.

Aside from such practical matters, it is the task of ionospheric physics during the Year to relate these various causes and effects to each other and to deduce a single consistent picture of events in the ionosphere and their effects on human affairs. This means that sunspots and solar flares must be observed at the same instant as the earth's magnetism is measured at as many points as possible on the earth's surface. The aurora must be observed in relation both to the solar flares and to magnetic variations. Measurements of the ionization in the various layers of the ionosphere must also be tied to the other variations, whether sunspots are involved or not. Ionospheric physics and meteorology are therefore both vitally concerned in the World Days and the World Intervals when special efforts will be made to obtain simultaneous measurements all over the world. By this time it is obvious that such world phenomena can be effectively studied only by world-wide co-operation among scientists of many nations and that to geophysics an occasional period such as the present Year is a necessity.

Since the major source of influence on the ionosphere is the sun, it will receive primary attention in the observatories that are equipped for solar studies. Both the magnificent eruptions of flares that spurt hundreds of thousands of miles into space from the face of the sun and the trembling variations in the sun's much fainter corona can now be observed on any clear day without waiting for a total eclipse to make them visible. This is the accomplishment of the coronagraph, a telescope so equipped that it blocks out the brilliant face of the sun completely and precisely, as an eclipse does, and thus permits the surrounding flames and luminous clouds to be photographed. Combined with a spectograph, which can detect the separate light from individual chemical elements on the sun, and with a motion picture camera to record action, the sublime drama is already recorded on film. The timing of such solar events with related effects in the ionosphere will be a major feature of the Year.

Gorgeous celestial ballets at the ends of the earth

THE aurora is almost certainly the consequence of a shower of particles from the sun, probably electrons and possibly protons (the nuclei of helium atoms) too. As they approach the earth these charged particles are deflected toward the magnetic poles of the earth and strike downward to ionize the upper air. With this much known, the exact course of events in the aurora is still unknown: the explanation of the gorgeous "curtains", the "draperies", the "rays" and the "arcs", the location about the poles, and the relation of the northern to the southern lights. For the first time a series of observing stations will be clustered about both the magnetic poles in the zones of maximum auroral activity. Radio contact has already been established between the stations at the two ends of the earth in order to link the two celestial ballets which cannot be seen at the same time from any point on earth. There is every reason to suppose that even more particles are showered on the earth by day than by night, which is to say that more can be expected on the side of the earth that faces the sun than on the back side. Yet the aurora is not visible by day. Efforts will therefore be made to track the aurora by radar and radio reflection during the daylight hours.

The radio-telescope, (see page 25) which has undergone rapid development in the past few years, will also do its share not only in "listening" to the sun but in detecting variations in the radio-waves from distant stars as related to change in the ionosphere.

The greatest mystery of the skies, however, are the cosmic rays. They are composed of the smallest of nuclear particles and reach the earth with energies measured in millions of millions of volts. With this high energy they are less affected by the earth's magnetic field than the particles which cause the aurora. But the actual particles from space seldom reach the lower atmosphere. These primary rays collide with atomic nuclei in the ionosphere or in the stratosphere to produce showers of secondary rays, composed of atomic fragments, which themselves have higher energies than any man-made particles. The properties of the primary particles can be deduced from the secondary ones in the showers but their origin cannot. It is not known from whence they come. It is possible that they—or some of them—originate on the sun or that their passage to earth is strongly influenced by the sun. This again means correlation with many other ionospheric observations.

Cont'd on next page

But cosmic rays are relatively rare and do not cause any mass effects;

WHERE THE SKY IS BLACK *(Continued)*

they must be studied individually. And because they change their nature as they crash downward, they need to be measured and identified at different altitudes. They have been caught on mountain tops, under the surface of deep lakes and in the depths of a few mines. Balloons have been used to study them to the reachable heights. But all this is too low and a cosmic-ray counter is needed that can ascend into the ionosphere. For this reason rocketry has become an invaluable instrument. It is a poor rocket these days that cannot climb 50 miles into the lower ionosphere and they have been sent up higher than 100 miles. During the Year rockets will be increasingly used to make brief excursions into these high levels and to bring back cosmic ray data. But more hope for valuable cosmic-ray information is borne by the artificial satellite which will cruise even beyond the ionosphere for a period of weeks, as described in the final article of this issue.

The Soviet Union and the United States have developed rocketry to a high degree. The disadvantage of the rocket is that it makes a vertical penetration of the ionosphere at a single spot and does not remain more than a brief moment at the top of its trajectory. Nevertheless important data have been collected. In a recent paper in the Journal of the British Interplanetary Society S.M. Poloskov and B.A. Mirtov of the U.S.S.R. describe a method of obtaining samples of air and of measuring wind velocities at altitudes of 50 miles and above by fitting a rocket with a series of mortars inside the shell which explode at predetermined altitudes and eject vacuum bottles to "some distance" from the rocket itself, hence from its combustion gases, where their valves open to collect samples of the air to be parachuted down for recovery and analysis.

Similarly, other mortars in the rocket eject cannisters containing 33 pounds of smoke-forming materials which are exploded at a distance from the rocket to form large smoke-clouds. Five such cannisters are exploded at different altitudes but the speed of the rocket makes them appear almost simultaneously in a vertical pattern which can be accurately measured from the ground with telescopes to determine their altitude and the speed of their motion with the ionospheric winds. Such observations have confirmed that these winds are of high velocity, always of the order of 200 to 300 feet per second, or about 150 miles per hour. The direction of the observed winds is from east to west in summer and from north to south in winter.

Another method for estimating ionospheric winds is by the study of meteors. These tiny wanderers through space, probably the debris of comets or ejected from comets during their passage around the sun, enter the ionosphere by the hundreds of millions daily, most of them mere specks of dust. They have had little scientific study except for the larger ones that survive the fall through the atmosphere and strike the earth. But scientists of the Soviet Union have set up a comprehensive programme for their study, which is described in the following article by Dr. V. V. Fedynsky, a distinguished member of the U.S.S.R. National Committee for the International Geophysical Year.

METEORS
Tiny wanderers through space

METEORS, visible to the naked eye as shooting-stars, blaze up and go out at a height of from 70 to 35 miles above the surface of the earth when iron or stone particles—meteoric bodies from interplanetary space—collide at a high velocity (from seven to 45 miles per second) with the atmosphere. The meteoric body is heated to a temperature of several thousand degrees and becomes highly incandescent; a column of ionized gas, the meteoric trail, is formed about it.

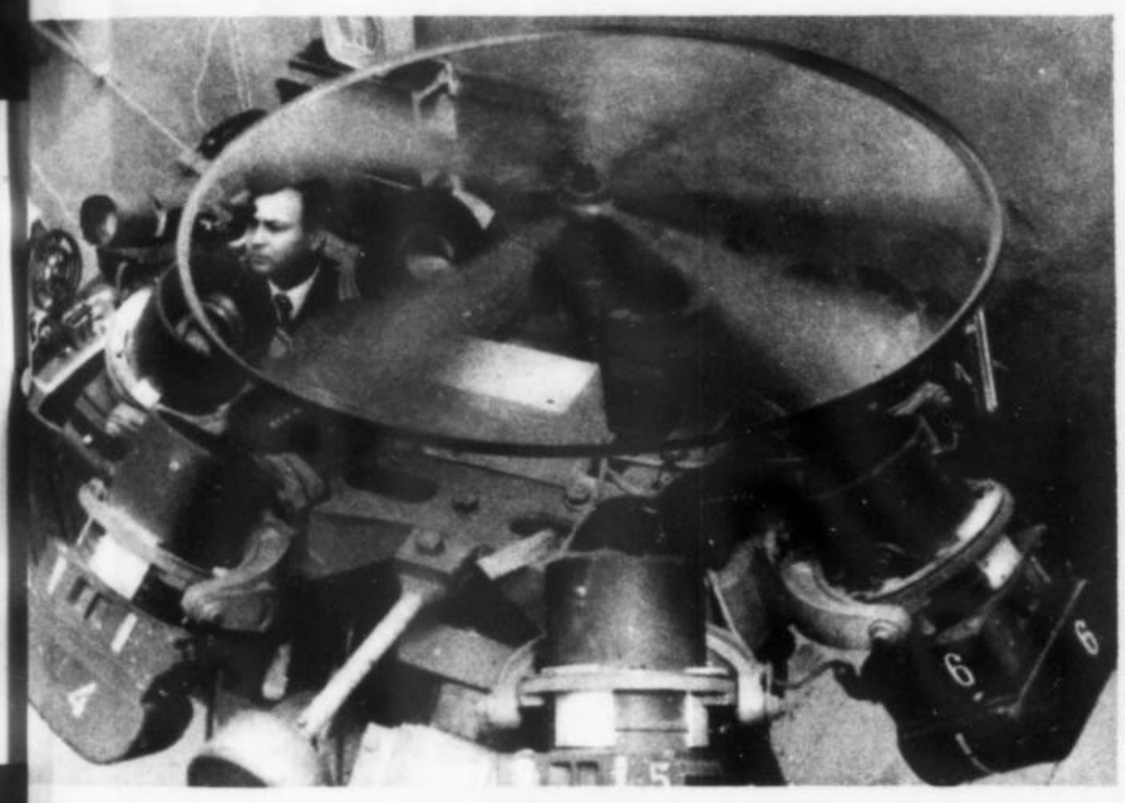
The diameter of the trail is several yards, and its length is usually from 15 to 18 miles. As it gradually disperses, the meteoric trail introduces electrically charged particles into the E layer of the ionosphere, thereby changing its composition. This trail can easily be registered by radar. By eye observation, and also with the help of radar, it is possible to follow the displacement of the meteoric trail, and thus to determine the direction and velocity of the wind at a height of 60 miles. From the height and velocity of a meteor's flight, and also the intensity of the light it emits, it is possible to calculate the pressure, density and temperature of the upper layers of the air in the region of its flight.

The programme for the observation of meteors in the U.S.S.R. was drawn up at international scientific conferences in Leningrad and Manchester in 1954, at which Czech and British scientists made suggestions on the study of meteors during the International Geophysical Year. The Soviet observations will be carried on parallel with observations in Czechoslovakia, the German Democratic Republic, Great Britain, the United States, Canada and other countries.

First in importance is to keep a constant check on the number of meteors and the nature of the ionized track they leave behind them. This work is to be done by radar installations in Kazan, Kharkov, Stalinabad, and Tomsk. Meteoric activity is to be registered day and night on all days set for universal geophysical observation, that is : during the World Meteorological Intervals, during the World Days, and on the Meteor Days when the earth comes into collision with large meteoric showers. Observations are also needed on such ordinary days, immediately preceding or following these intervals, as are required for comparison. In all, the radar installations are to be working about 100 days a year. This will provide sufficiently complete data on the earth's collisions with meteoric matter in cosmic space. It will give a clear enough idea of the nature of the action of meteors on the ionosphere and on the connexion between meteoric ionization and the anomalous audibility of radio broadcasts and visibility of television broadcasts.

It is important to compare the intensity of ionization with the luminosity of meteors in order to determine the mechanics of the emission of energy by meteoric bodies when they come into collision with the atmosphere. In order to do this, visual registration of the meteors by unaided eye observation, and also with short-focus binoculars of large field of view, will be practised in conjunction with the radar observations of meteors. Amateur astronomers who are interested in astronomy but do not make a profession of it will thus take part in scientific research.

Bright meteors will be photographed with cameras of high light-gathering power. Photographic observation of meteors can only be carried on when the sky is dark and clear, best of all in the south. In the U.S.S.R., such observations have been carried on for a long time now by the Astronomical Observatory of the Tadjik Academy of Sciences in Stalinabad, and the Astrophysical Laboratory of the Institute of Geophysics of the Turkmen Academy of Sciences in Ashkhabad. By the beginning of the Year these observatories will have received more powerful meteoric photographic apparatus and set up observation points in the mountains outside the cities mentioned above. The Astronomical observatories of the Kiev and Odessa Universities in the Ukraine have again organized the photographic observation of meteors.



Hundreds of millions of meteors—most of them mere specks of dust—enter the earth's atmosphere every day and burn out in the ionosphere which acts as a shield against this meteoric bombardment. They have had relatively little scientific study except for the larger ones that survive the fall through the atmosphere But scientists of the Soviet Union have set up a comprehensive programme for observing meteors during the I.G.Y. linked up with similar studies in other countries. Opposite page, (top photo) very bright meteor, visible to the naked eye as a "shooting star", recorded by the Stalinabad Astronomical Observatory. Snake-like form of a meteoric train seen at Penza in central Russia (bottom photo). The wind at the height of 40 to 55 miles where it was observed varied in direction at different levels, thus bending the train to form a figure "3". Left, meteor "patrol" at Stalinabad with cameras to photograph meteoric activity during the I.G.Y.

U.S.S.R. official photos

In order to determine the altitude and velocity of a meteor's flight, the meteor must be photographed with two cameras set up from 12 to 25 miles apart. At one of these points the apparent velocity of the meteor's flight must be determined with the aid of a rotating shutter of the "windmill" type. The obturator covers the lens of the camera from 30 to 50, and even 100 times a second. The trail of a meteor photographed through an obturator shows as a broken line. A double photograph of a meteor (combined print of two photographs of the same meteor taken from different places), makes it possible to calculate the height, velocity and slowing up of the meteor, as well as its magnitude. Having all these data, it is not difficult to determine the physical properties of the upper layers of the atmosphere along the path of the meteor—the density, pressure and temperature of the air.

The winds in the ionosphere can easily be observed with the aid of radar. To do this, observations are made of the shifting in the position of the meteoric trail which produces radio echoes. The trains of very bright meteors can also be observed visually through a telescope, or successive photographs can be taken of them which register their movement in space. Observation of the movement of meteor trails is to be carried out in Ashkhabad and Stalinabad.

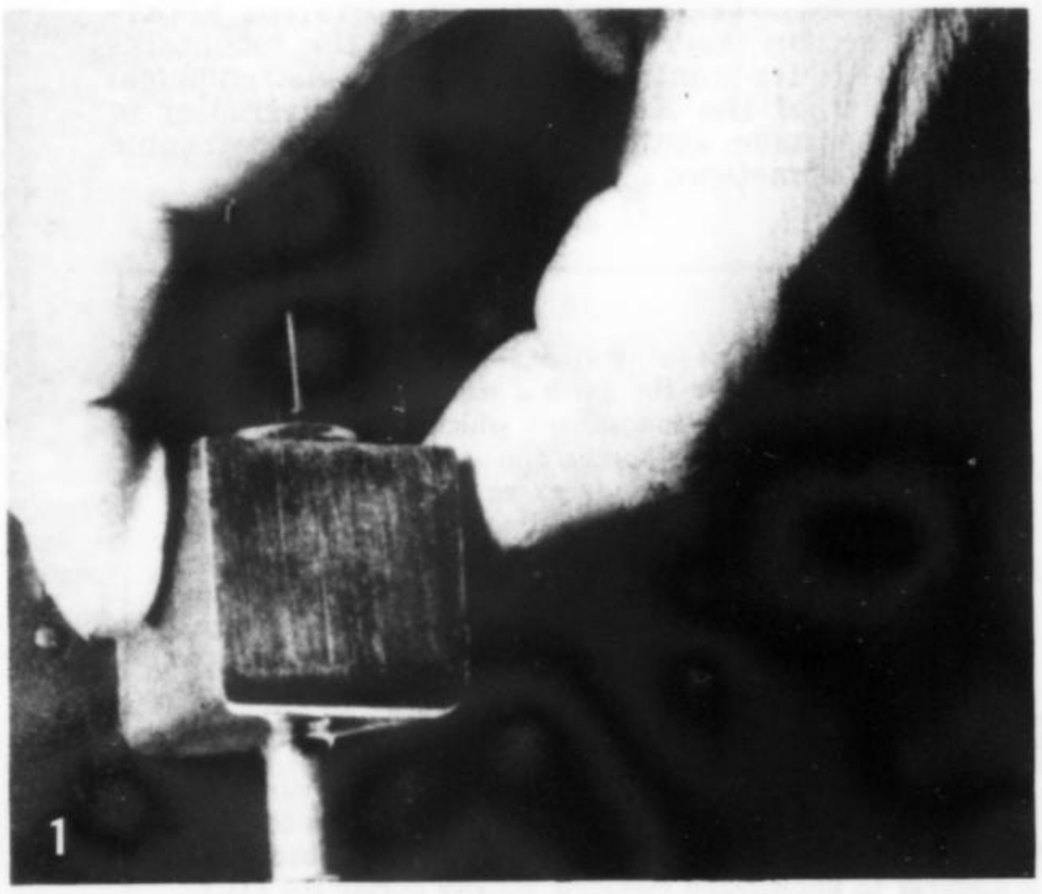
The above article is based on a special report prepared for THE UNESCO COURIER *by Dr. V.V. Fedynsky, a member of the U.S.S.R. National Committee for the I.G.Y.*

MAN-MADE SATELLITE

the first step into outer space

THE most ambitious project of the International Geophysical Year and the most imaginative project in the history of science will reach out into space, possibly as far as 1,800 miles above the earth's surface, to observe and report on conditions there. The launching of a 20-inch sphere, filled with electronic instruments and transmitters to a total weight of about 22 pounds, and setting it into an orbit around the earth at a velocity of approximately 18,000 miles per hour will be an incomparable achievement—not because it is spectacular, but because it is precisely planned, mathematically predicted in advance, and because it requires the use of many fabulous devices that have been perfected only recently, a focussing of many sciences and the integrated co-operation of thousands of experts.

No one man will get the credit or make the first voyage into unknown space, as Columbus did, or Magellan. This present explorer will be a superhuman electronic brain that will go where no man can go, yet will do man's bidding, investigate and report continuously to its creators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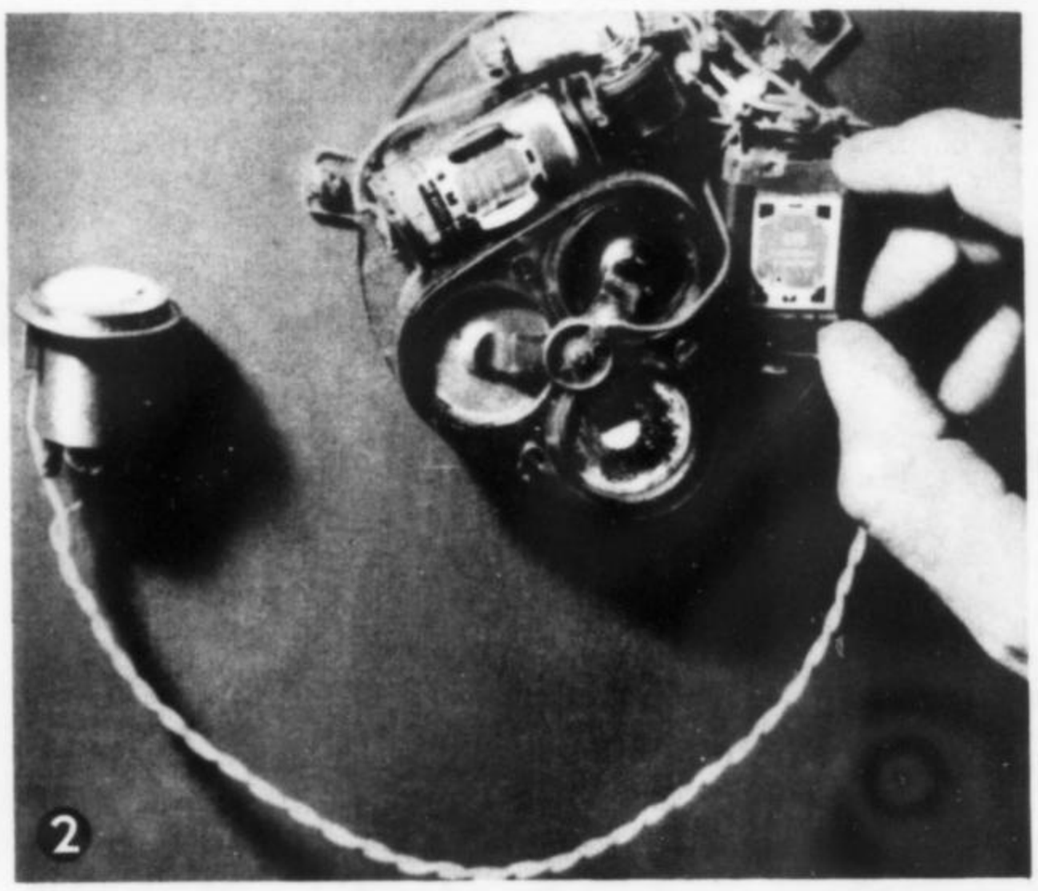
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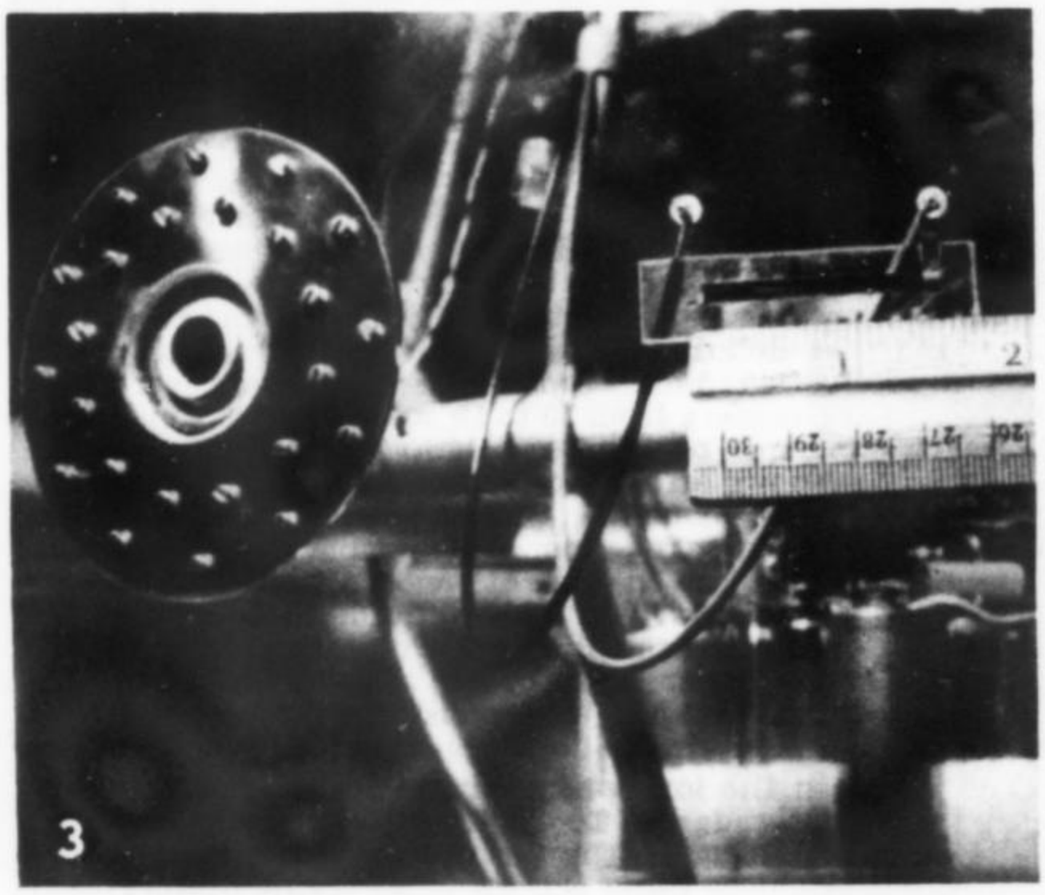
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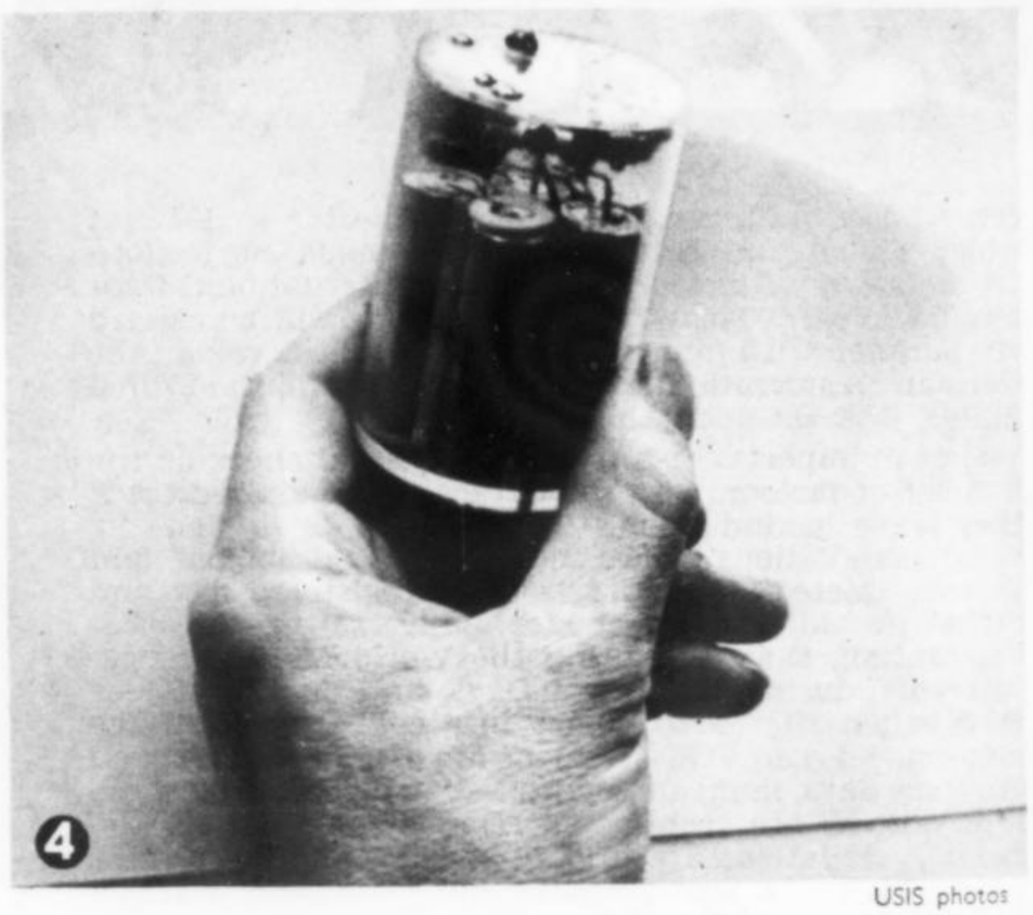
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USIS photos

LONG-PLAYING ROCKET. Earth satellite to be launched from the United States will be used by I.G.Y. scientists in two basic ways. First it will provide a target to be tracked—by radio and optically—from the ground. Second it will collect, memorize and transmit to the earth data on the upper regions through which it passes. Opposite page, (upper photo), cylinder containing electronic equipment is inserted in outer shell of satellite. Closely packed instruments represent almost half its total weight of about 22 pounds. These are revealed (lower photo) as satellite model is lifted out of its plastic shell. In foreground are removable plastic antennas. Above, the miniaturised instruments which will make the first sustained observations in space. It is for this reason that satellite has been labelled the "long-playing rocket". (1) Pressure gauge will tell if meteorite pierces metal shell of satellite. (2) Meter will measure intensity of sun's ultra-violet rays. (3) Solar cell (on left) will harness sun power to produce electrical impulse as satellite emerges from darkness into daylight on each successive orbit, resetting memory unit that stores data for transmission to earth. Erosion gauge (right) will record any damage to shining, golden surface of sphere by meteorites. (4) "Minitrack" radio transmitter, equipped with mercury batteries, has range of 4,000 miles.

and masters far below, glide through silent space for a few weeks, then end its meteoric career in a brilliant flash.

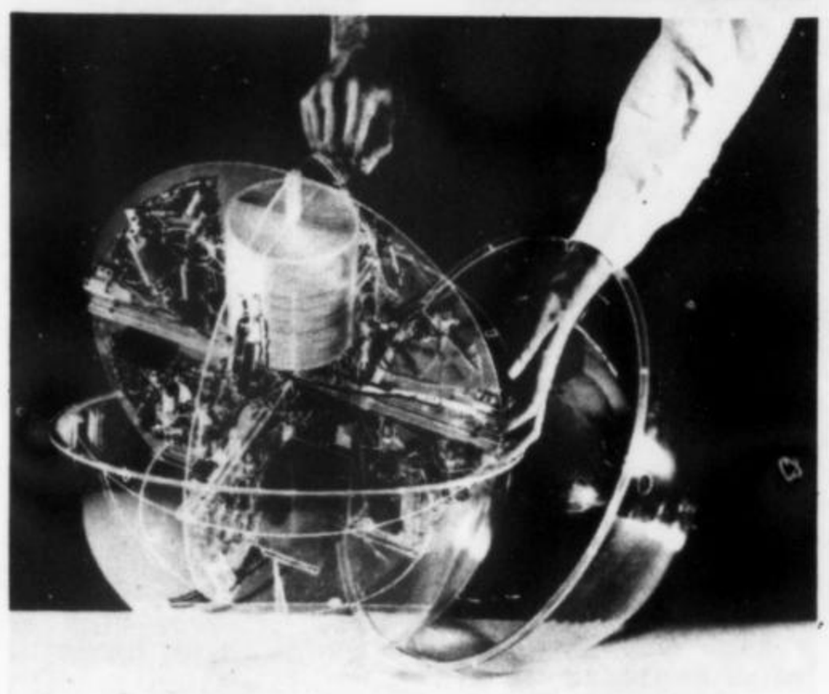
Why? Because man wants to know. Every boy in every land throughout the ages has gazed on the clouds and blue sky, and on the stars at night, and has wondered what is beyond. During the centuries of ignorance and mysticism men filled the heavens with visions. Then, with increasing knowledge, the air became a material substance and the blue of the sky lost its reality to become only an optical effect of refracted light, and beyond that—nothing, cold, empty space interspersed with remote stars and galaxies. But that was a passing stage.

Because men have ever wanted to know more—which is their chief distinction from the animals—space is no longer called empty. The atmosphere gradually thins out; it has no surface like that of the ocean. There is enough of it even a thousand miles up to give a slowing friction to the proposed satellite. There are enough particles of solid matter cruising independently through space to show the instant flash of a meteor, heated by this friction of our air and burned to dust, almost anywhere and at any hour of night and millions of them, in all, every 24 hours.

There are the rays called "cosmic" to imply that they come from remote regions of the universe, though no one knows from where. They are minute fragments of atoms, fragments of atomic nuclei, and "fundamental" particles that are still smaller, all of them crashing into the top of the atmosphere with incredible energy. Then there are the tremendous showers of electrons that are ejected from the sun during its colossal storms and are projected to us across 93 million miles of space. And there is sunlight itself. All these impinge upon the earth in a constant barrage but only the dumb, helpless atoms of the outermost air receive their impact and message.

The proposed satellite will be a temporary observatory for them all, limited in its powers as in its existence, but far more than earthbound man has ever before used. It will police the topmost sky. What it discovers and reveals to science will no doubt be fragmentary, and will bring more questions than answers, but it is an essential step toward the eventual conquest of space.

Both the United States and the Soviet Union have announced plans for launching earth satellites but the United States has given full detailed publicity to its programme so that this article is devoted to the American project. The launching site is at Cape Canaveral on the long Florida peninsula that extends the Atlantic coast of the United States into the Caribbean Sea. The satellite itself is small but the rocket system to lift it on high and to give it an adequate velocity in its orbit is massive. Its total length is 72 feet, composed of three stages. The design, construction and launching of the rocket is in the hands of the U.S. Naval-Research laboratory which is spending $110 million on the project. The large first-stage rocket will have a thrust of 27,000 pounds and will propel the entire vehicle upwards with a gradual inclination of the path eastward over the Atlantic Ocean. When its fuel is exhausted the first-stage rocket will drop off into the sea and the second-stage motor will be ignited.



This will drive the remaining vehicle to an altitude of about 140 miles and it will then coast, without power, another 700 miles on an inclined path to reach the desired altitude of between 250 and 300 miles. At this altitude the nose cone that protects the sphere of the satellite itself will be dropped, a pinwheel array of small jets will spin the vehicle to stabilise its flight, and then the third-stage rocket will give another burst of power to propel the satellite into its desired orbit at a velocity of 18,000 miles per hour.

At this speed the centrifugal force of its horizontal motion around the earth will be sufficient to counteract the force of gravity at that altitude so that it will continue to circle the earth in its orbit exactly as the moon does at a much greater distance of 250,000 miles. If the satellite were perfectly launched it could attain a circular orbit. But such accurate control is not possible and the actual orbit will probably be an ellipse and the distance of the satellite from the earth will vary from 2-300 miles to 800-1,500 miles. The orbit will not be exactly to the east, parallel to the earth's equator but at an angle with it so that its position as it goes round the earth will vary from 35 degrees of latitude north of the equator to 35 degrees south of it. Thus in its various circuits a band about 70 degrees wide will be covered by the satellite and scientists of a large number of nations will be able to observe and measure it.

At a velocity of 18,000 miles, it will not be able to encircle the earth in an hour, for the circumference of the earth is 24,000 miles. It will pass completely around the earth in approximately one and a half hours.

The most important information to be furnished by the satellite will come from tracing its orbit. Its position will be carefully measured and timed from many points on the earth's surface and its orbit will then be precisely calculated. The first problem will be to find the satellite in the sky early in its flight. This cannot be done by the accurate cameras that will later fix its position because such cameras can cover only a small portion of the sky and must be aimed in advance at an area through which the satellite will later pass. The original location of the satellite and a preliminary calculation of its orbit will be done by timing of the radio-waves that are constantly emitted from the satellite. Radio receiving stations will be situated along its path to detect the direction from which these signals come.

This system is known as Minitrack. Each minitrack station will have two sets of receivers, 200 metres apart on the ground. The difference in the time required for a signal from the small transmitter in the satellite to reach the two receivers will give a fairly accurate measurement of the location of a satellite in the sky. One set of two receivers will measure its position in the east-west direction and the other set its position in the north-south direction. Such stations will be located at Washington D.C. and Savannah, Georgia, in the U.S.A.; at Havana, Cuba; at Antigua in the British West Indies; Quito, Ecuador; Lima, Peru; Antofagasta, Chile; Santiago, Chile; San Diego, California, U.S.A.; and one in Australia.

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It is possible, however, that the radio-

MAN-MADE SATELLITE *(Continued)*

FLYING OBSERVATORY 1,200 MILES HIGH

transmitter within the satellite will somehow fail to operate. In that case the minitrack stations would be useless. To guard against this contingency large numbers of volunteer sky searchers, scattered all over the world, will be on duty with powerful binoculars to locate it. With groups of such binoculars at many points, a large region of the heavens can be covered and the satellite can be kept under observation. Thus the orbit can be approximately established even without the radio-transmitter. When the orbit has been approximately established by the minitrack measurements of the binocular observers, precise observations of its positions will be made by a series of special "Schmidt" cameras that are provided with timing devices so accurate that they will measure the instant of taking the photograph of the sky within a thousandth of a second. Such optical observing stations will be established in New Mexico and Florida in the U.S.A.; and Bloemfontein, South Africa; Mauna Loa, Hawaii; Tokyo, Japan; Curacao, Netherlands Antilles; Cadiz, Spain; Tehran, Iran; Arequipa, Peru; Villa Dolores, Argentina; and in India and Australia.

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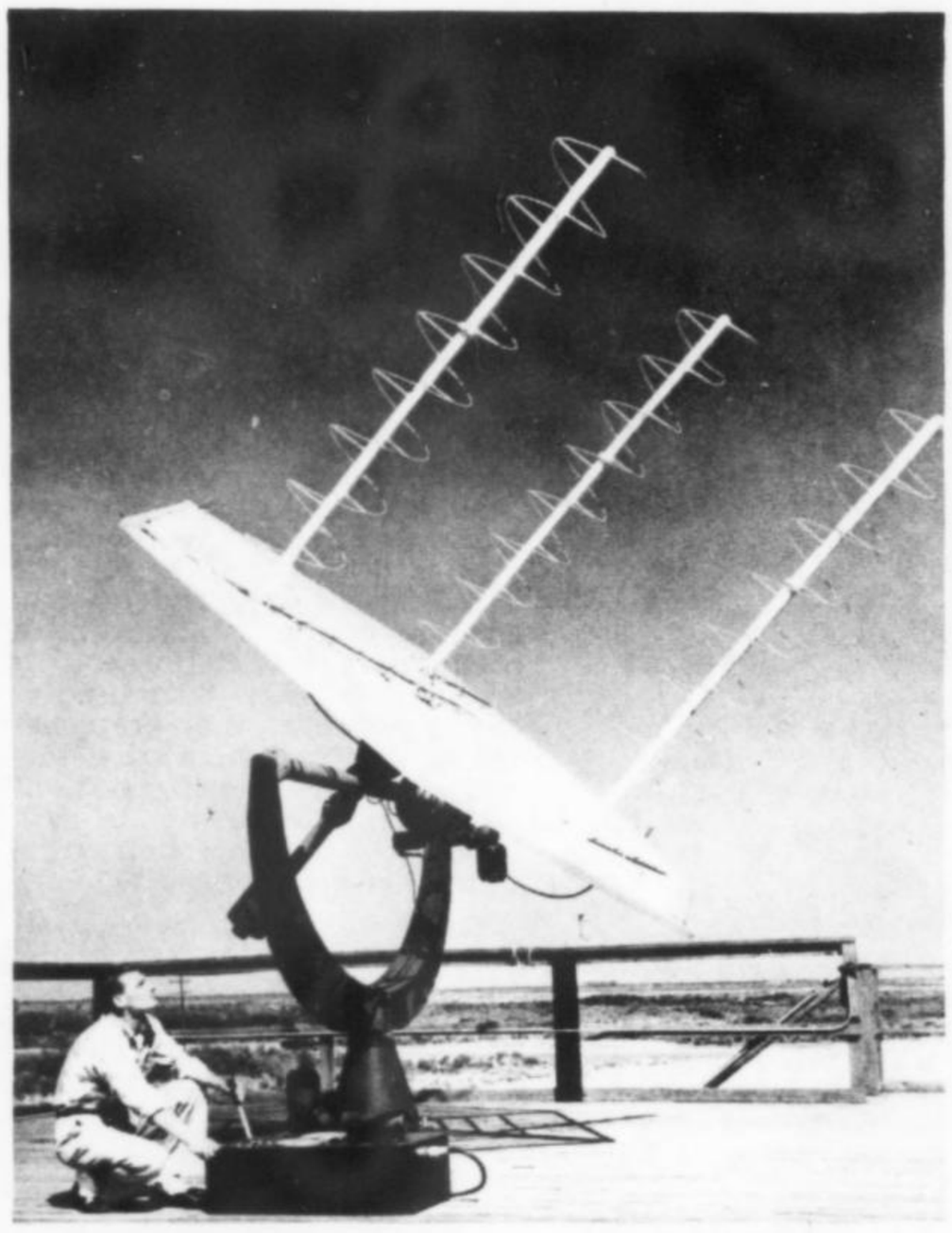
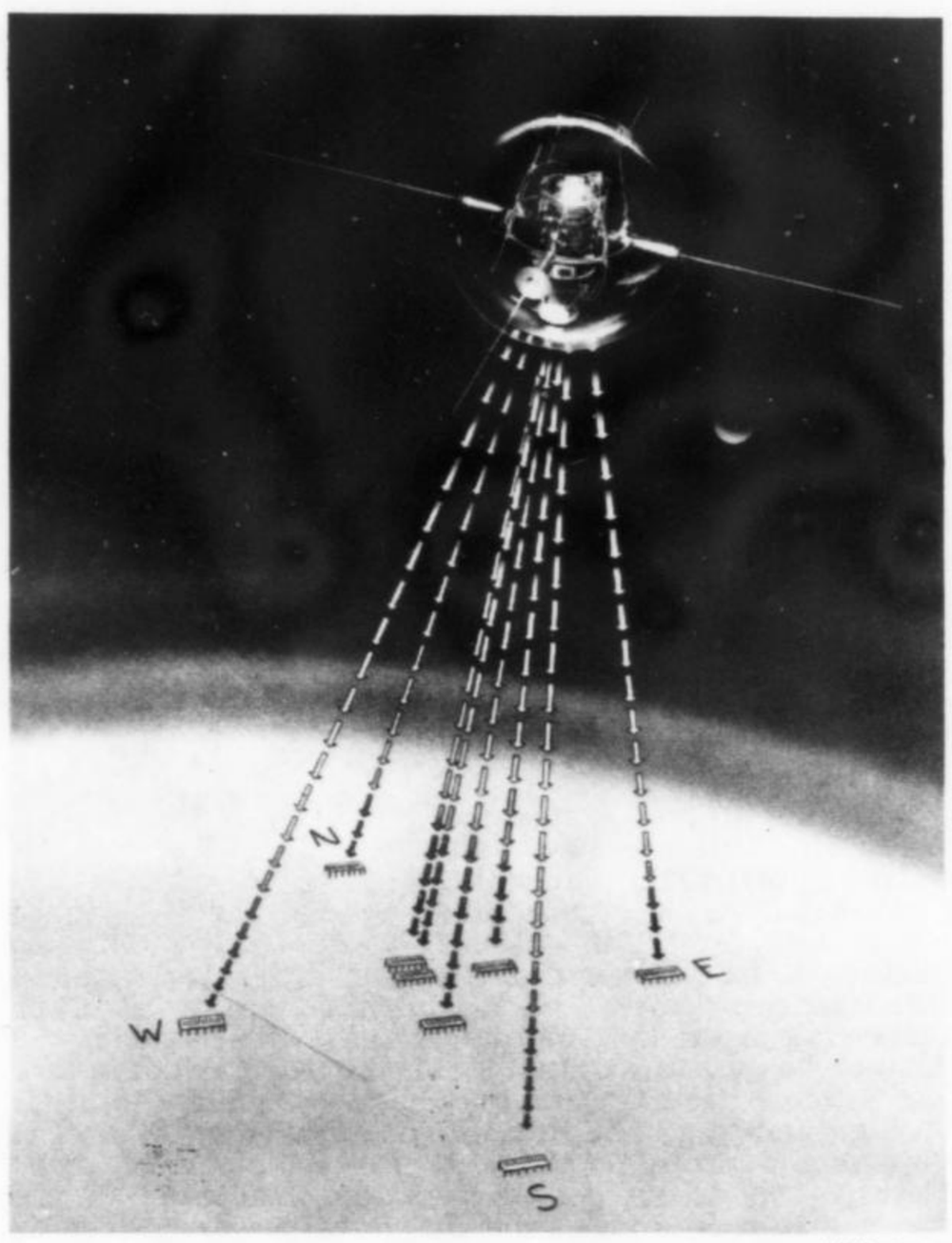
THE reason for the high accuracy of the orbital observations and calculations is not merely to establish the orbit itself but to observe its small irregularities and changes in the velocity of the satellite. These will give important further information. A gradual reduction of velocity is expected as a result of the friction of the thin upper air. Very little is now known of the density of the air at that height but the geometry of the satellite's orbit and observations of its flight will permit calculations of the air density.

If the composition of the earth were quite uniform its gravitational pull, or gravitational field, would also be uniform. In that case the orbit of the satellite would be a simple, regular ellipse. But irregularities in its orbit, known as perturbations, will undoubtedly be observed by the use of accurate Schmidt cameras. Such variations in the orbit will permit calculations of the distribution of mass within the earth and these, in turn, should yield information on the composition of the earth's crust. This may prove to be one of the most valuable results of the whole project.

But there is more. The earth is not a sphere but is flattened at the poles into the oblate shape of a spheroid. The exact magnitude of this distortion needs to be known to permit accurate determinations of latitude and longitude. Here too knowledge of the exact path that the satellite takes will give valuable information.

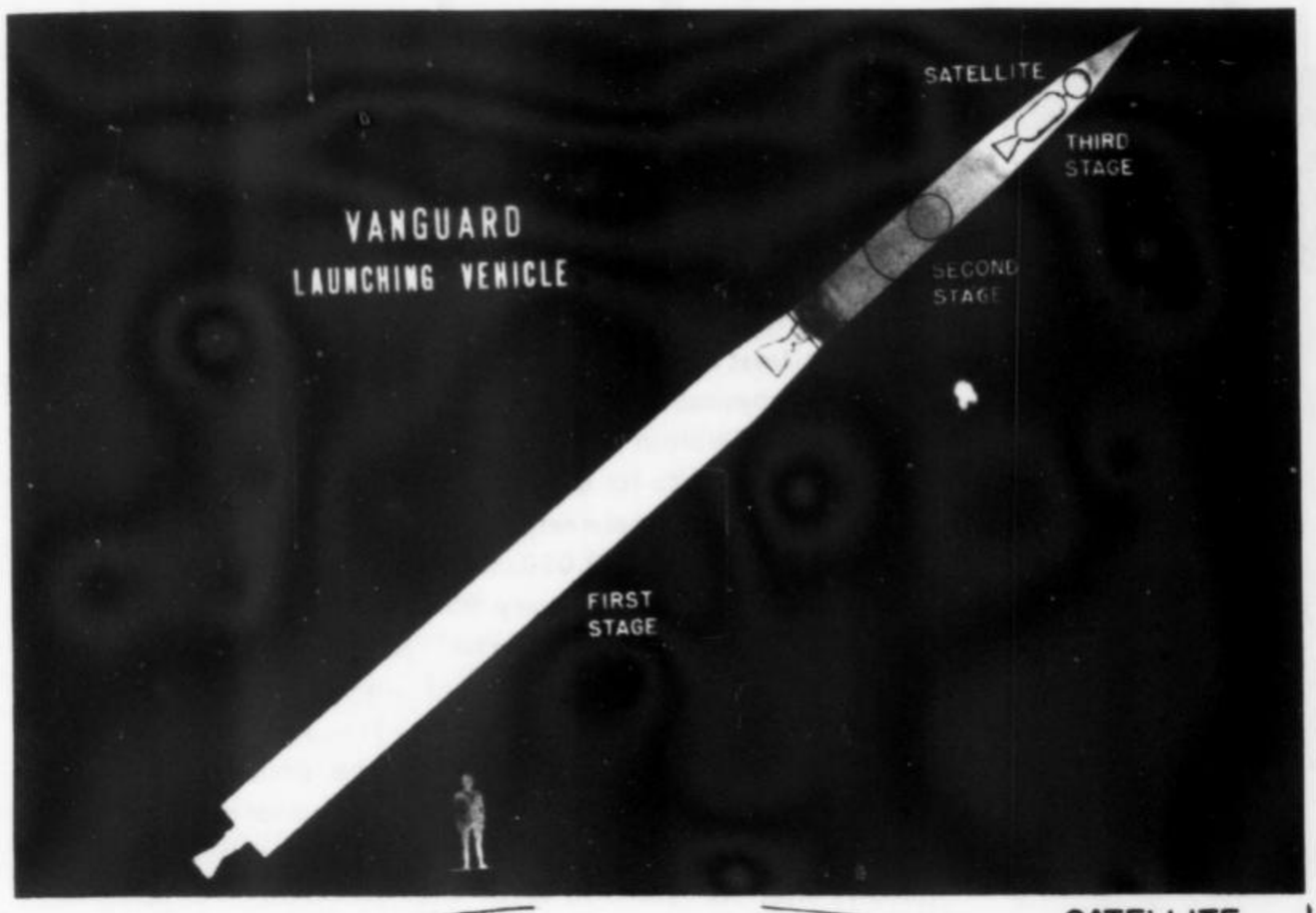
Finally, the orbital measurements will also give information on the electrical conditions of the upper atmosphere, i.e. on the number of ions, or electrical charges, in the air. This requires a double observation of the orbit: one by the Schmidt cameras, the other by the radio signals that come from the transmitter in the satellite. If the upper air were not electrified the radio signals would come to earth in straight lines. But when they go through electrified layers they will be bent, or refracted, much as a beam of light is refracted when it passes from air to water or passes through the glass in a lens. Thus when the angle of the radio beam is accurately measured, it will not be correct, because of this refraction. But light waves are not bent, or refracted, by electrical charges. So the altitude of the satellite as measured by the optical cameras, will be correct. The difference between the optical measurement and the radio measurement will indicate the



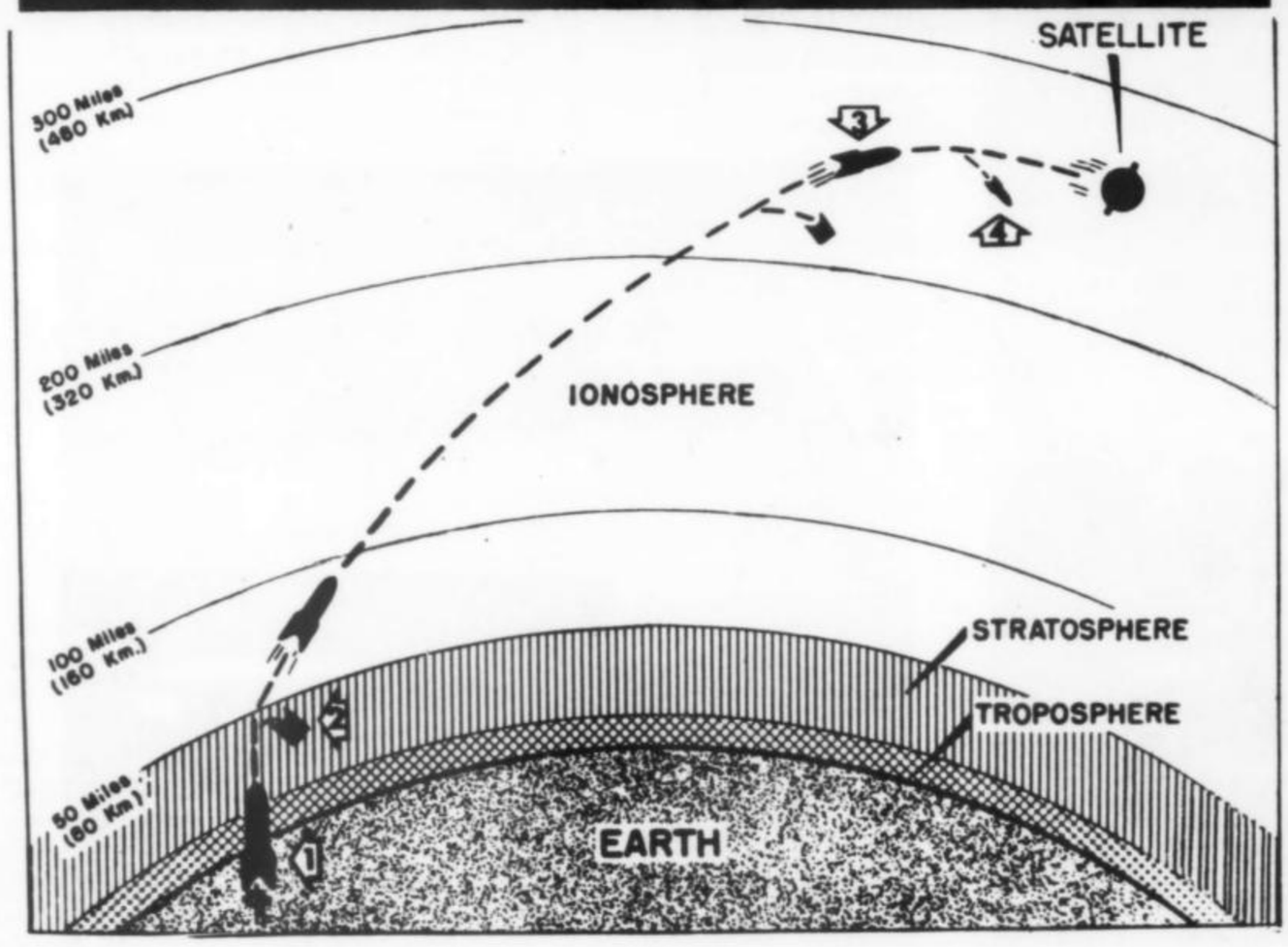


USIS photos

RADIO SIGNALS will be used to track artificial satellite as it sweeps over the earth at 18,000 miles per hour. Drawing, right, shows arrangement of supersensitive ground receivers, called Minitrack, which will be located in a chain in the United States and South America to pick up signals from satellite's miniature radio transmitter. (See map, pages 18/19). Accurate tracking of satellite from the ground offers a unique opportunity for a closer study of the shape of the earth. Scientists have developed a variety of equipment for launching and tracking the satellite. Left, telemeter antenna at a satellite launching area used to monitor test performances of rocket launching vehicles.



ELEVEN-TON ROCKET FOR 22-LB. SATELLITE



The earth satellites in the I.G.Y. programme of the U.S.A. will be launched from a huge, three-stage rocket called the Vanguard (upper left), 72 ft. long and weighing 11 tons (satellite it will carry weighs about 22 lbs). Idea of its size is given by human figure drawn in proportion alongside. Drawing, lower left, shows the stages in the flight of the Vanguard rocket vehicle. The first-stage rocket propels the vehicle from the launching point (1) to an altitude of 36 miles (2) and then falls away back to earth. The second-stage rocket now takes over and carries the vehicle, first under power and later on coasting flight, to a height of about 300 miles. The second-stage separates and the third-stage now boosts the speed to 18,000 miles per hour at which point the satellite is launched into its orbit. At (4) third-stage rocket falls away.

USIS photos

amount of refraction by the electrical ions and will permit a calculation of the electrical charge characteristics of the thin air in the ionosphere.

These are all items of information that can be obtained from the ground by the observation of the satellite's orbit. But the satellite itself contains instruments for making observations which will be automatically reported to the ground by radio while it is in flight. Both the space inside the small sphere and the permissible weight are very limited. But among the experiments that the satellite may conduct are a number that are of great interest to men of science.

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THE most important is the measurement of the invisible energy that reaches the earth from the sun. It is not visible to human eyes because the light-waves are too short. They are shorter than those of purple or violet light, hence are known as ultra-violet. Much of the radiation can hardly be called light at all, with waves as short as those of the penetrating X-rays. This radiation is absorbed in the upper layers of the atmosphere where it is transformed, causes ionization and the strange luminous effect that is called airglow. Eventually the energy is either reflected into space or reaches the lower atmosphere where it affects the weather and the climate. The satellite gives a unique opportunity to study this energy at the edge of space, before it has been absorbed and transformed. What is more, this flying observatory is expected to stay aloft for at least two weeks and will measure the variations of the solar radiation during all its flight. If in this period there should be a solar flare, a great outburst of energy from a "sunspot", the data provide by the instruments in the satellite "would be of the greatest possible scientific interest", says the U.S. National Committee.

Another primary function of the satellite is to explore the motion of electrical charges in the air at that height, and the flow of thin but very large electric currents. It is supposed that these are responsible for the rapid fluctuations of the earth's magnetism. Since the satellite will be cruising over a very large part of the earth's surface every day and, in its elliptical orbit, will vary in height from 200 miles to 1,200 miles, it will make an overall map of electrical conditions and presumably will furnish clues to the origin of "magnetic storms." It would be of great practical value to understand these storms enough to permit predicting them.

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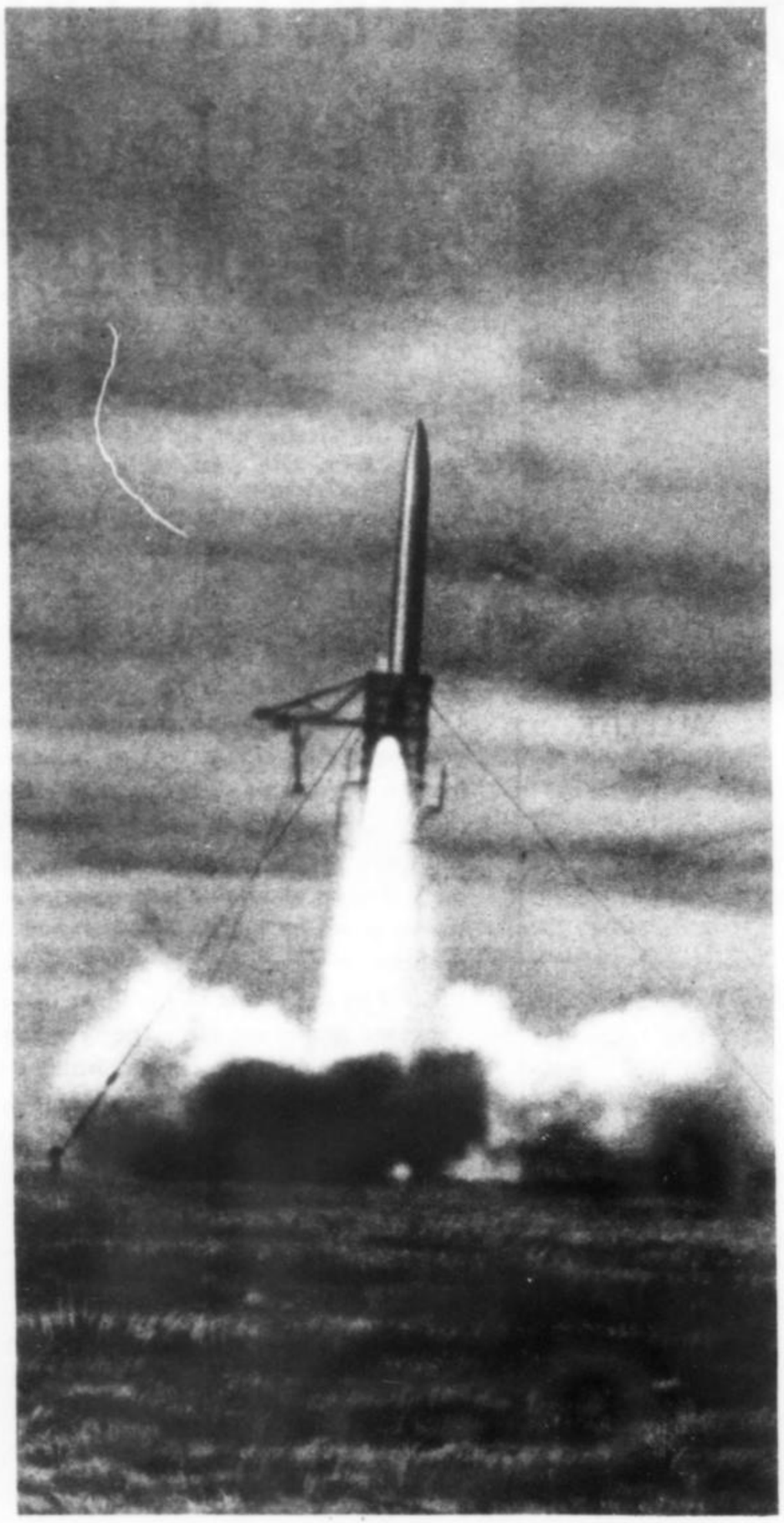
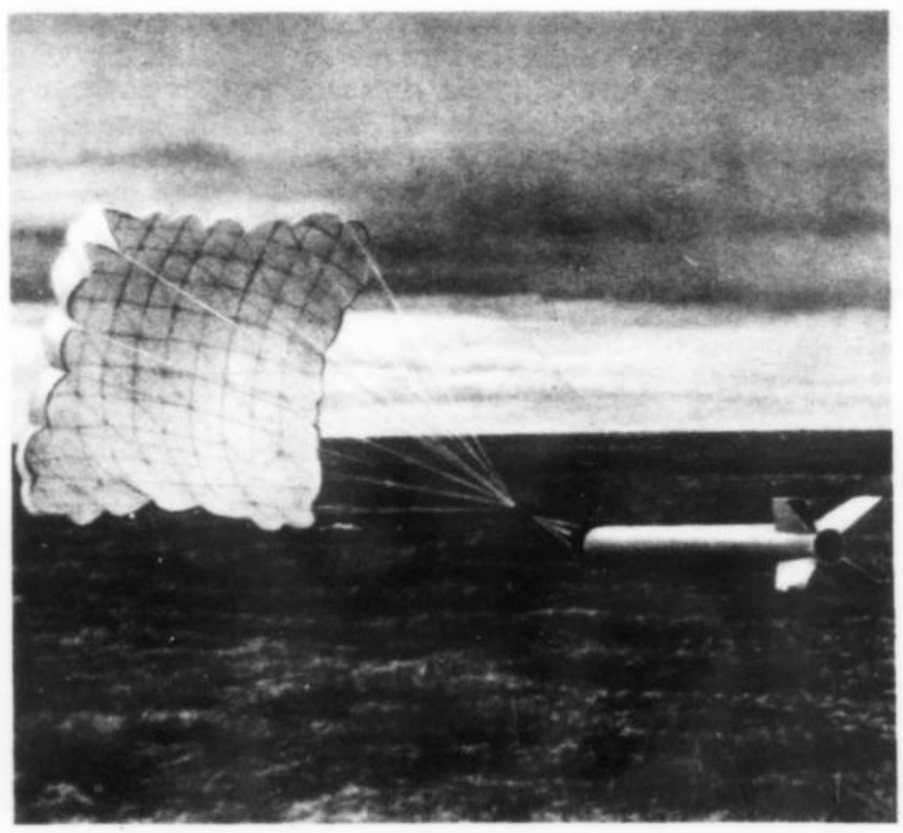


A GIRDLE ROUND THE EARTH IN 90 MINUTES

Scientists in the Soviet Union have announced that they will launch at least one artificial earth satellite during the International Geophysical Year. Of spherical form, the Soviet satellite will be carried aloft in the nose of a multi-stage launching vehicle. Once propelled into its orbit, the satellite will girdle the earth at altitudes varying between 120 and 300 miles at a speed of between 15,000 and 18,000 miles per hour. This speed will bring it around the globe every 90 minutes so that in 24 hours it will make 16 complete circles. Recording instruments in the satellite will make observations which will be radioed to specially equipped ground stations. The rocket which will launch the satellite into its orbit will be similar to the one shown here, which has been specially designed for studies in the upper atmosphere. Left, Soviet rocket being launched and (below) after its return to earth with parachute still attached.

Official Soviet photos



MAN-MADE SATELLITE *(Continued)*

Cosmic rays are another mystery which has never been investigated at a level above the atmosphere where they are still unaffected by collision with earthly atoms. The satellite will contain a counter for these rays to measure their total number. After two weeks of such counting over a wide area of the earth the results are expected at least to be of sufficient importance to justify more elaborate study of cosmic rays by later satellites.

Information on the total heat received from the sun and on its variation, which is the fundamental factor in weather phenomena, will also be valuable in an understanding of the major weather changes and possibly in the prediction of future hurricanes and typhoons. Also the satellite will observe the cloud cover of the earth continuously and on a world-wide scale, thus providing another basis for weather studies.

Finally, there will be many routine observations of minor significance, such as a microphone system to record the number of collisions with tiny meteorites, pressure measurements to record any leakage in case of a puncture, and observations on corrosion and the temperature of the shell of the Satellite.

The date for the launching of this superb experiment, this supreme test of man's present command of his world and its forces, this first small venture to the borders of cosmic space, has not yet been set. But it will be in 1958, a year which will go down in history for that reason, just as 1939 will forever be remembered for the first observed fission of a few single atoms of uranium in a peaceful research laboratory in Berlin. The superhuman but captive explorer will not survive to be shown to future generations in a museum of science. In a few weeks—two to four probably, six perhaps—the friction of whatever air there is so high up will slow it down, decrease its centrifugal force so that gravity will slowly pull it downward, then faster into thicker air and more friction and higher temperature until every speck of it is vaporized and burns into dust. The man-made moon will end as a meteorite and disappear in a flash of brilliant light, a blaze of well-earned glory.

From the Unesco Newsroom...

MAN MEASURES THE UNIVERSE

Since the announcement in the May, 1957 issue of The Unesco Courier that copies of Unesco's pamphlet, "Man Measures The Universe", could be obtained free of charge by subscribers, some 5,000 readers have requested and received copies of it. As stocks are now exhausted we regret that no new requests can be met. The pamphlet describes in detail Unesco's fourth travelling exhibition, "Man Measures the Universe" which is now visiting Danzig, after being on view in Paris, Liège, Brussels, Ghent, Madrid, The Hague, Warsaw and Cracow. After its Polish tour the exhibition will go to Czechoslovakia in December. When it closes at the end of the year it will have been viewed by some 500,000 people.

SWISS & SWEDISH SWOP JOBS: Eight girls employed by co-operative stores in Zurich have been studying diligently after the day's work for the past year, learning Swedish. And now their chance has come to use the new words, for recently they set off for a year's work in Stockholm. The Swiss girls, whose ages range from 19 to 24, are well prepared for their new jobs in grocery shops of the Swedish Co-operative Federation, for they have also studied Swedish trade instructions, price lists and commodity lists. Meanwhile, six Stockholm girls have been studying German in preparation for taking up jobs in Zurich as one-year "guests" of the Swiss Co-operative Federation. These exchanges are sponsored by the International Co-operative Alliance under a plan initiated by UNESCO to enable men and women in many walks of life to work abroad at their own trade for periods of three to twelve months. The over-all plan for the exchange is operated through international trade unions and co-operative organizations working with UNESCO. It is limited to persons in European member states of UNESCO. Applications are received by the worker's own co-operative or trade union. UNESCO pays for travel between countries.

■ **NUCLEAR POWER AT HOME:** *Power from the atom will soon provide electricity for towns and villages in France's chateau country. Work has already started on the site of a new nuclear power plant to be constructed near Chinon in the Loire Valley. The plant, which is to start operating in* 1959, *will be the first in France to produce "nuclear" current for domestic and industrial purposes. Another station is in the south-west, but it provides energy for research purposes only. The Loire site was chosen for the new plant because the Valley has no hydro-electric resources.*

CITY UNDER A CITY: An ancient city wall, 3,300 years old, has been discovered at Chengchow by an archaeological team now exploring the site. This is the oldest city wall found in China and has been dated to the early Shang dynasty (1700 BC to 1200 BC). Most parts of the city wall (between 13 and 55 feet wide) as well as the ancient city itself lie buried beneath Chengchow city. Over 10,000 ancient buildings and relics have been found around the buried city in the past three years, including tombs, workshops, tools, weapons and works of art.

■ **UNESCO AIDS YOUTH TRAVEL:** *A world-wide programme for educational travel by selected members of youth groups this year has been put into operation by* UNESCO. *Forty young people of* 32 *countries will go abroad in the* 1957 *operation of the* UNESCO *Youth Travel Grant plan, many of them on long journeys, for study of out-of-school educational methods for youth. This year's programme includes travel for study in Europe, Africa, Southeast Asia, the Far East, Australia, the West Indies, Central and South America and North America. Some of those travelling under the plan will go to international work camps and to holiday camps. Others will study Red Cross youth organizational work, student movements, youth hostels, young worker activities, youth legislation and governmental programmes for youth. Youth organizations will receive the travellers, for training periods of from* 3 *to* 12 *months. Those selected hold responsible posts in their organizations, and are to use in their own countries the knowledge and experience gained on their journeys. They range in age from* 20 *to* 30. *Their study travel is from region to region—not merely to near countries—and their transportation is paid in full or in part by* UNESCO.

IVORY TREASURE RESTORED: How the priceless collection of ancient ivory art objects of the Sakiz Treasure of Iran was saved through scientific restoration was recently described by a UNESCO expert who worked for six months in the Museum of Teheran on these relics from Kurdistan, believed to be more than 2,500 years old. Friedrich Smoorenburg, Dutch specialist, who had been assigned by UNESCO to assist the Iranian Government in the restoration work, reported that about 100 pieces of ivory, mostly in plate carvings, could not have lasted more than another year. Buried for 2,655 years, the ivories had been reduced to calcium which under slight pressure would become dust. Now, after treatment with humidity and carbonic acid, the pieces have become strong and hard again. And by the use of a cellulose compound as an adhesive, the elements of the plates and the few sculptures have been joined together to form the ancient designs. They are now protected with paraffin. The ivories were part of a chest-full of treasure including gold and jewels which was discovered by shepherds a few years ago.

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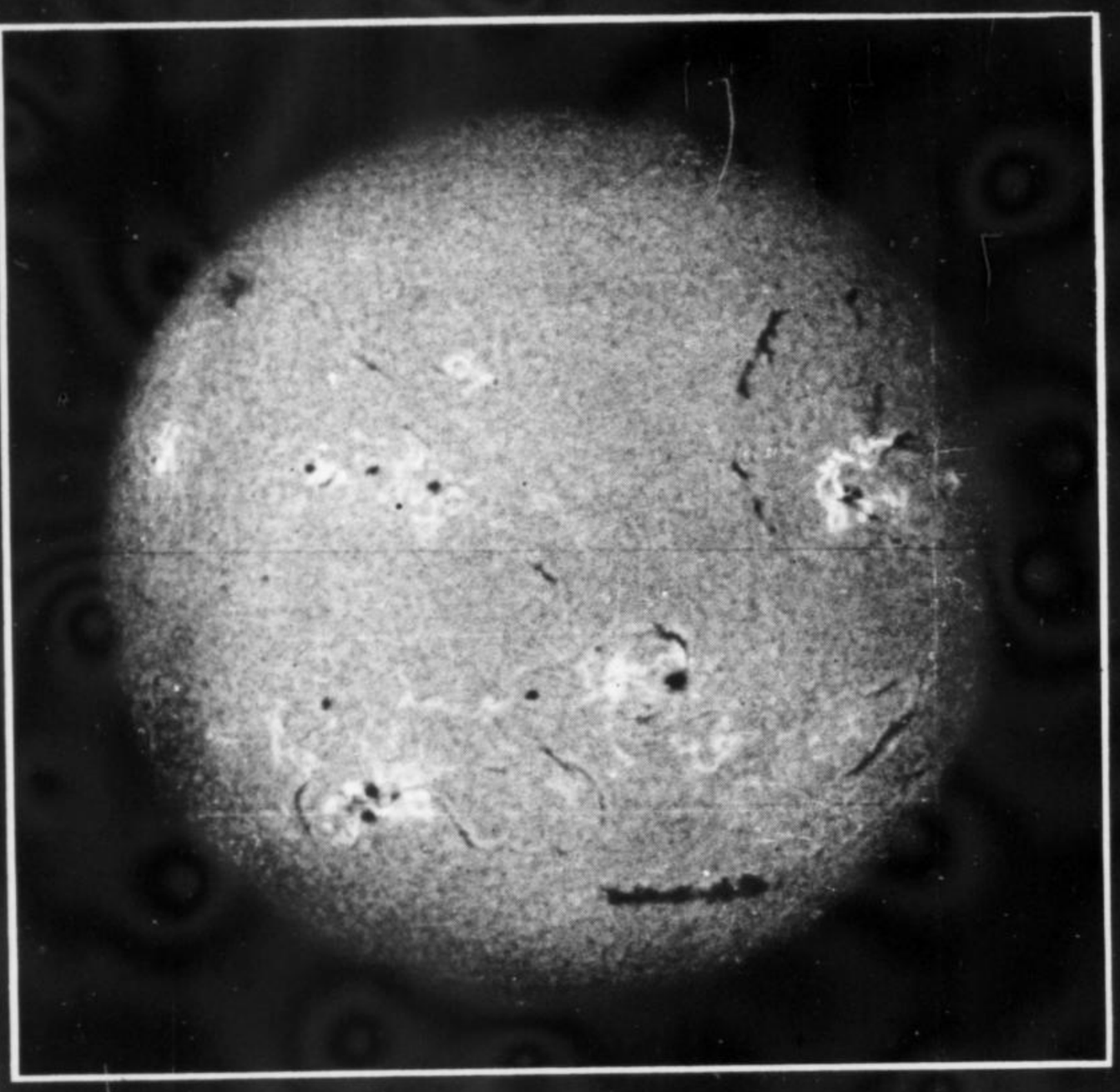

FLAMING GA ES SPEWED O UT FROM THE S UN

On July 3, 1957—third day of the ternational Geophysical Year—a gigan flare occurred on the sun. (Solar flares re explosive events which spew out seous matter into space, sometimes ris g to a height of half a million miles at a eed of 500 miles a second). The event w s photographed at the Meudon Observat y near Paris, by a method which elimin es all the light radiations from the sun except one, in this case the H-alpha hydrogen line, by which the photographs were taken. Top photo, taken at 7.22 hours (Universal Time) shows start of flare on right. Second, taken 40 minutes later, reveals state of flare just after its maximum phase. Meudon Observatory, chosen as world centre for collection of solar observations concerning chromospheric flares and the sudden disappearance of solar flare prominences during the I.G.Y., will receive reports from some 50 stations in all parts of the world.

Photos Meudon Observatory, France